

Watershed Assessment of Portions of the Clark's Fork Yellowstone, Bighorn Lake, and Shoshone Subbasins, Montana and Wyoming

Prepared for:

Bureau of Land Management,
Montana / Dakotas State Offices

By:

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EXECUTIVE SUMMARY

This report summarizes results from a multi-scale ecological assessment of seven watersheds in the Clark's Fork Yellowstone, Bighorn Lake, and Shoshone River subbasins in southern Montana and Wyoming. The area is unique in that it lies at the junction of three broad Level III ecoregions: the Wyoming Basin, the Middle Rockies, and the Northwestern Great Plains. It is bounded by the Beartooth Mountains on the west and the Pryor Mountains on the east. The Pryor Mountains and foothills are areas of especially high endemism for plants. The goal of the project was to provide landscape-level assessments of watershed health and integrity, as well as site-specific evaluations of wetland and aquatic condition within the 1,248,164 acre assessment area. This was accomplished using both broad-scale GIS analysis and field sampling.

The value of watershed-level assessments lies in identifying areas where impacts are currently occurring or may occur, rather than merely documenting effects that have already occurred. By combining both site-level and watershed-level assessments, it is possible to select areas where management can make a substantial difference in future wetland and aquatic health.

Our broad-scale GIS assessment examined underlying biological diversity, measured current conditions, and evaluated potential threats. Several key findings emerged from the GIS data analysis:

- Across the Montana portion of the assessment area, the BLM owns or manages approximately 217,000 acres, or 25% of the land.
- Across the assessment area as a whole, 50% of the land cover is shrubland, 32% is grassland, and 6% is forest. Wetlands make up less than 2% of the landcover. Pasture and cropland account for 9%. Both public and private grasslands and shrublands are used primarily for cattle grazing.
- In the Montana portion of the assessment area, there are currently 317 reservoirs ranging in size from 500 acres to less than 1 acre, 153 surface water diversions (dams, ditches, headgates, etc.)

and 228 ground water diversions. Silver Tip Creek has the highest number of diversions, at 114, followed by Elbow Creek with 99.

- In terms of hydrology, topography, and vegetation communities, the Sage Creek 5th code HUC has the most complexity of the watersheds we evaluated, while the Silver Tip 5th code HUC has the lowest.
- All the watersheds received positive scores on a Composite Watershed Condition Index, which evaluates natural cover, stream corridor land use, riparian loss, and road disturbances. The Crooked Creek watershed had the highest score, while Silver Tip Creek and Bear Creek had the lowest. The Silver Tip watershed has extensive mining and agricultural impacts, while much of the Bear Creek watershed has lost riparian forests along tributary streams due to overgrazing, and its lower reaches have a heavy concentration of agriculture.
- The Bear Creek and Silver Tip Creek watersheds also had the highest scores on the Composite Threat Index, which assesses the potential risk from oil and gas extraction, riparian grazing, and residential development. The Bighorn River-Layout Creek watershed had the lowest score.

We found in general, roads and road crossings are a disturbance in the assessment area. This was borne out by our field surveys, where we noted most roads follow valleys, and are often within eyesight of the stream. Road density is highest in the Sage Creek watershed and lowest in the Bighorn-Layout watershed, which also has the fewest road crossings per stream mile. Sage, Silver Tip and Bear Creek all have the highest number of road crossings per stream mile (0.63, 0.64, and 0.63 respectively).

- Our fine-scale rapid assessments focused on wetlands, ponds, springs and streams. We conducted Proper Functioning Condition (PFC) assessments at 73 sites and detailed aquatic surveys at thirteen sites. From the PFC surveys, we found most

(51) sites were in proper functioning condition. Only 12 sites were found to be functioning at risk with a downward trend, and only four were non-functioning. Sites on BLM-managed land did not appear to be in any better or worse condition than sites under other management.

- When we compared the results of our surveys at BLM-managed sites where PFC surveys had been conducted in 2005, we found seven sites had degraded, 19 had improved, and 10 had stayed the same. In general, weeds and grazing were the most common source of impairment.
- In our aquatic surveys, we found significant environmental factors in this region (e.g. oil and gas fields, water diversions, improper grazing practices) appear to impair the biological health of some aquatic ecological systems, notably Silver Tip Creek, South Fork Bridger Creek, and Grove Creek.
- Three of the 13 visited lotic sites had good habitat quality, as ranked by at least one habitat assessment method. Five of the 13 sites were ranked slightly impaired and five moderately to severely impaired.
- High sediment loading was measured at both Silver Tip Creek sites, and in Grove Creek and South Fork Bridger Creek. The water conductivity values taken at both Silver Tip Creek sites and Clark's Fork Yellowstone Site #1 were above the threshold ($>3,000\mu\text{s}$) for the water quality impairment level.
- Three native fish species, the longnose dace (*Rhinichthys cataractae*), longnose and white suckers (*Catostomus catostomus* and *C. commersoni*), and 112 macroinvertebrate taxa, were identified from the 13 aquatic survey sites. No Species of Concern were found.

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INTRODUCTION

Scope of the Report

This assessment includes seven 5th code hydrologic units (HUCs) or watersheds¹ (Figure 1) covering roughly 1.25 million acres in Bighorn, Carbon and Yellowstone counties in south-central Montana and in Park and Big Horn counties in north-central Wyoming. The watersheds are part of three subbasins (4th code HUCs) that ultimately drain into the Yellowstone River: the Clark's Fork Yellowstone, the Shoshone, and Bighorn Lake.

The goal of this project was to provide landscape-level assessments of watershed health and integrity, as well as site-specific evaluations of riparian areas, wetlands and aquatic resources under the jurisdiction of the Bureau of Land Management (BLM) in Montana. Field sampling of terrestrial and aquatic sites provided detailed information on the composition and distribution of plant, invertebrate, and fish communities in sites under BLM management in Montana. We conducted a broad GIS analysis to evaluate watershed condition across the contributing watersheds in both states, using indices of watershed integrity developed in earlier watershed assessments (Vance 2005, Vance et al. 2006, Vance and Stagliano 2007).

The Ecological Setting: Level III and IV Ecoregions

The assessment area lies at the junction of three broad Level III ecoregions: the Wyoming Basin, the Middle Rockies, and the Northwestern Great Plains (Omernik 1987). Five Level IV ecoregions dominate: the Bighorn Basin and the Bighorn Salt Desert Shrub Basin within the Wyoming Basin; the Pryor-Bighorn Foothills and Central Grasslands within the Northwestern Great Plains; and the Dry, Mid-elevation Sedimentary Mountains within the Middle Rockies (Figure 2).

The unglaciated **Bighorn Basin** ecoregion straddles the Montana and Wyoming border, and is characterized by rolling plains, terraces, and alluvial fans (Chapman et al. 2004). Most of the Silver Tip

watershed and part of the Sage Creek watershed are in this ecoregion. Elevations range from 5,000 to 7,500 feet. Surface geology consists primarily of Quaternary alluvium, colluvium, outwash deposits, and eolian deposits derived from Tertiary and Cretaceous sedimentary rock. Portions of the assessment area have extensive areas of shale and bentonite clay, while others feature the light-colored sandstones, gray sandy shales, and coal beds of the Mesa Verde Formation. Rock outcrops occur with some frequency. Soils are primarily entisols and aridisols. Streams and rivers originating in mountains have moderate gradient with cobble-sized substrates of granite, volcanic rock or limestone. Channels are frequently incised, and streams are rarely perennial, although ephemeral streams often become perennial during irrigation season because of return flows. In general, the hydrology of the area has been severely altered by the action of irrigation diversion ditches. Wetlands occur sporadically along the few perennial streams and rivers, especially in areas of poor drainage, although there are a few small aspen-dominated wetlands near the headwaters of Grove Creek in the Bear Creek watershed. Annual precipitation averages 8-14 inches.

Land cover in the Bighorn Basin is primarily shrubland dominated by sagebrush steppe (Figure 3). Common species include Wyoming big sagebrush (*Artemisia tridentata* ssp. *wyomingensis*), western wheatgrass (*Pascopyrum smithii*), bluebunch wheatgrass (*Pseudoroegneria spicata*), needle-and-thread grass (*Hesperostipa comata*), blue grama (*Bouteloua gracilis*), Sandberg bluegrass (*Poa secunda*), junegrass (*Koeleria macrantha*), rabbitbrush (*Chrysothamnus* spp.), and fringed sage (*Artemisia frigida*). Cottonwoods (*Populus* spp.) and non-native Russian olive (*Elaeagnus angustifolia*) grow in riparian areas where streams and rivers are not deeply incised. The primary land use is grazing, although there is extensive irrigated agriculture, especially along the major rivers and streams. Oil and gas production occur throughout the basin, as do areas of bentonite clay production.

¹ HUC nomenclature corresponds to common usage as follows: 4th code HUCs are subbasins; 5th code HUCs are watersheds; and 6th code HUCs are subwatersheds.

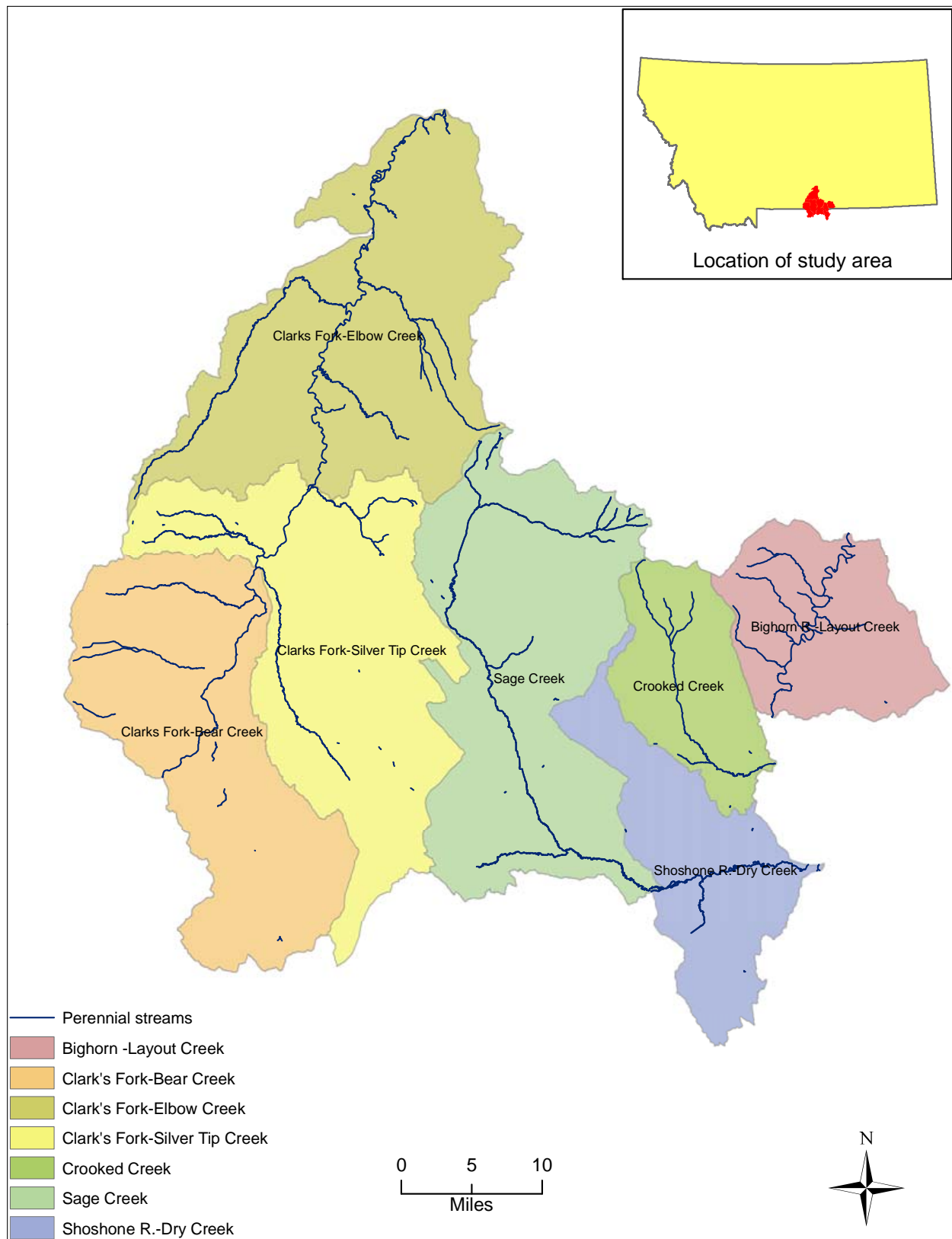


Figure 1. Assessment area watersheds.

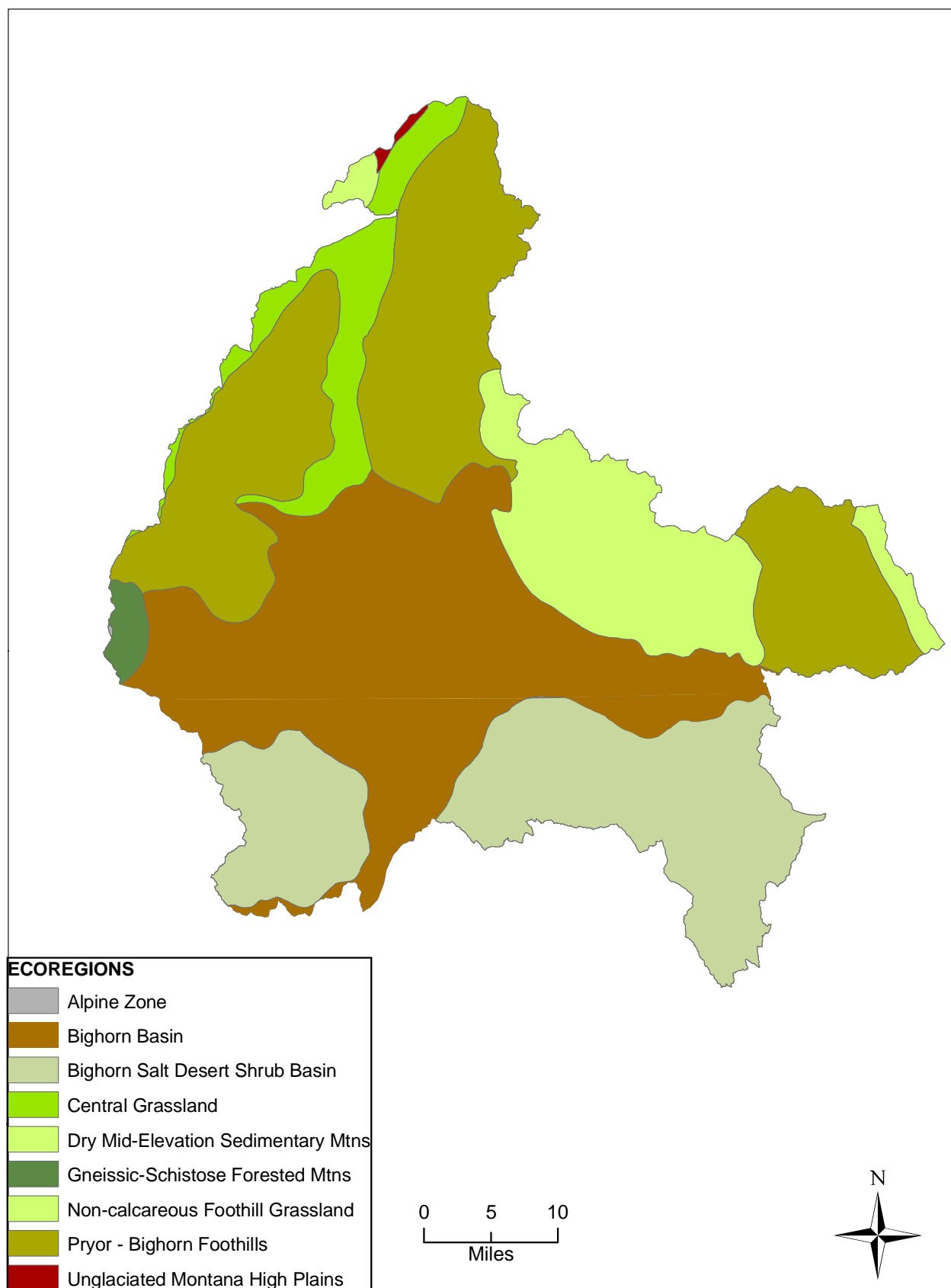


Figure 2. Level IV ecoregions included in the assessment area.



Figure 3. Bighorn Basin shrublands.

The **Salt Desert Shrub Basin** in the southern (Wyoming) part of the assessment area is similarly unglaciated, with plains, level floodplains and terraces, and gently undulating alluvial fans (Chapman et al. 2004). The lower part of the Sage Creek 5th code HUC and the Dry Creek 5th code HUC both extend into this ecoregion. In general, perennial streams are uncommon, and even intermittent streams flow for only limited periods. Ephemeral streams are the norm. Because substrates are often fine textured or platy shale, many streambeds are incised, flowing into playa areas. Playas are seasonally wet, and have high concentrations of soluble salts. Surface geology in this ecoregion is characteristically Quaternary alluvium and colluvium, with gravel and fan deposits, and some areas of dune sand and loess. Underlying geology is Tertiary and Cretaceous sandstone, claystone and siltstone, with some areas of oil and shale marl. As in the Bighorn Basin, soils are generally entisols and aridisols. Average precipitation is between 6 and 10 inches. Land cover is mostly desert shrubland with alkaline tolerant shrubs and grasses dominating. Greasewood (*Sarcobatus vermiculatus*), shadscale (*Atriplex confertifolia*), bud sage (*Picrothamnus desertorum*), big sage (*Artemisia tridentata*) and Gardner saltbrush (*Atriplex gardneri*) make up the shrublands, while sandy areas typically feature alkali cordgrass (*Spartina gracilis*), Indian ricegrass (*Oryzopsis hymenoides*), blowout grass (*Redfieldia flexuosa*), needle-and-thread, and alkali wildrye (*Leymus simplex*). Land use is primarily grazing and gas and oil production (Figure 4).



Figure 4. Oil Fields near Powell, Wyoming.

Examples of the **Pryor-Bighorn Foothill Level IV** ecoregion are found on the northeastern and northwestern flanks of the assessment area (the Bear Creek and Elbow Creek 5th code HUCs), and in the extreme eastern portion (the Layout Creek 5th code HUC). These are the high benches and dissected sedimentary foothills that rise from the valley floors where the Clark's Fork Yellowstone and Bighorn rivers flow (Figure 5). Typically this ecoregion has cool, productive streams with fine gravel and cobble substrates. When wetlands occur, they are primarily the result of seepage from reservoirs or poor drainage caused by road and railroad berms, although there are also some greasewood flats and saline depressions. Cottonwoods and willows grow along streams, especially in the east-facing valleys, although many of these are in a decadent condition as a result of stream incision. Surface geology is mostly Quaternary alluvium and colluvium and Paleozoic/Mesozoic sediments. Soils on the east are generally mollisols, paleustolls, entisols and inceptisols, while in the west they are predominately mollisols, entisols and aridisols. Annual precipitation ranges from 10-20 inches. Land cover is mixed-grass prairie dominated by western wheatgrass, fescues (*Festuca* spp.), junegrass, and fringed sage, with some scattered juniper (*Juniperus communis*) and occasionally ponderosa pine (*Pinus ponderosa*) woodlands. Land use is primarily livestock grazing.



Figure 5. Pryor-Bighorn foothills.

The **Central Grassland** ecoregion is found along the Clark's Fork Yellowstone Valley. The lower part of the Silver Tip Creek watershed and most of the Elbow Creek watershed are in this ecoregion, which is characterized by a flat plain with Quaternary terrace deposits and alluvium over fine-grained, non-carbonate sedimentary sandstones and shales (Woods et al. 2002). Soils are mostly entisols, mollisols, inceptisols and alfisols. Irrigation with drawals, returns, and impoundments have dramatically altered the hydrology in the area. Annual rainfall averages between 14 and 16 inches. In uncropped areas, land cover consists of mixed-grass prairie dominated by blue grama, needlegrass, western wheatgrass, junegrass, and Sandberg bluegrass, with rabbitbrush and fringed sage. Along the Clark's Fork, cottonwood forests are thickly interspersed with non-native Russian olive. Irrigated agriculture is common, with most land cropped to alfalfa (Figure 6). Non-cropped land is primarily range and pasture. Land use is mostly farming and low- to mid-density residential.



Figure 6. Irrigated fields in the central grasslands.

The **Dry, Mid-Elevation Sedimentary Mountain** ecoregion lies above the Pryor-Bighorn Foothill ecoregion on the east of the assessment area in the Pryor Mountains. Crooked Creek, Sage Creek and portions of Layout Creek watersheds originate in this area. Although this ecoregion type was glaciated in many areas of the Middle Rockies, this was not true of the Pryors. Geologically, the Pryor Mountains consist of carbonate-rich sedimentary rock (primarily Madison Formation limestone) with numerous caves and faults. Springs and seeps occur frequently (Figure 7). Although the mountains are semi-arid, there are several spring-fed perennial creeks flowing over boulder, cobble, and bedrock substrates. Soils are primarily alfisols, mollisols and entisols. Precipitation in the Pryors ranges from 12-20 inches. At the highest elevations, land cover is comprised of subalpine fir (*Abies lasiocarpa*) communities interspersed with fescue-dominated grasslands dominated by Idaho fescue (*Festuca idahoensis*). Douglas fir (*Pseudotsuga menziesii*) and limber pine (*Pinus flexilis*) grow on lower elevation slopes. Major undergrowth species include one-seeded ninebark (*Physocarpus monogyna*), shinyleaf spirea (*Spiraea betulifolia*) and common juniper (*Juniperus communis*), with hawthorn (*Crataegus douglasii*), snowberry (*Symphoricarpos albus*) and serviceberry (*Amelanchier* spp.) in riparian canyons. In general, this is an area of high endemism for vegetation. Land use in the area is limited to recreation and some quarrying.



Figure 7. Spring on Piney Creek.

Other Level IV ecoregions in the assessment area include the subalpine fir- and Douglas fir-dominated **Gneissic-Schistose Forested Mountains**, more characteristic of the Red Lodge area, found in the upper part of the Bear Creek watershed, especially near the headwaters of Grove Creek (Figure 8). There is also a very small patch of **Alpine Zone** ecoregion near the headwaters of Grove Creek, and small areas of **Non-calcareous Foothill Grassland**



Figure 8. Forested mountains, upper Grove Creek.

and **Unglaciaded Montana High Plains**, both near Bridger, Montana.

Hydrology

The study area includes three major rivers: the Clark's Fork of the Yellowstone, the Bighorn, and the Shoshone (Figure 9).

The Clark's Fork of the Yellowstone River originates in the Beartooth Mountains approximately 4 miles northeast of Cooke City. It flows southeast into Wyoming, then northeast back to Montana, past the towns of Belfry, Bridger, Fromberg, and Edgar before joining the Yellowstone River near Laurel, Montana. Flows are driven by snowmelt, with daily means flows of >5000 cubic feet per second (cfs) typically occurring in mid-June at Belfry. In the last three years, however, peak flows have occurred in late May. Agricultural withdrawal and drying of tributary streams deplete the river during the summer. By September, daily mean discharge at Belfry is less than 200 cfs.

The Bighorn River begins in Wyoming, where it is known as the Wind River before becoming the Bighorn River near the town of Thermopolis. It flows through the eastern portion of the study area into the Crow reservation, where the Yellowtail Dam creates Bighorn Lake. Below the dam, it is joined by the Little Bighorn River near Hardin, then flows into the Yellowstone some 50 miles downriver. It too is a snowmelt-driven system, with peak flows in late May and early June.

The Shoshone River also has its headwaters in Wyoming, in the Absaroka Range in Yellowstone National Park. It is impounded by the Buffalo Bill Dam near Cody, Wyoming, and is heavily diverted for agricultural irrigation through a series of dams and diversions collectively known as the Shoshone Project, run by the Bureau of Reclamation. Return flows and releases eventually join the Bighorn River near Lovell, Wyoming.

Natural wetlands are uncommon. Preliminary mapping of wetlands in the Montana portion of the study area shows only 120 acres of natural wetlands. Most of these are palustrine emergent systems (about 70 acres) associated with streams

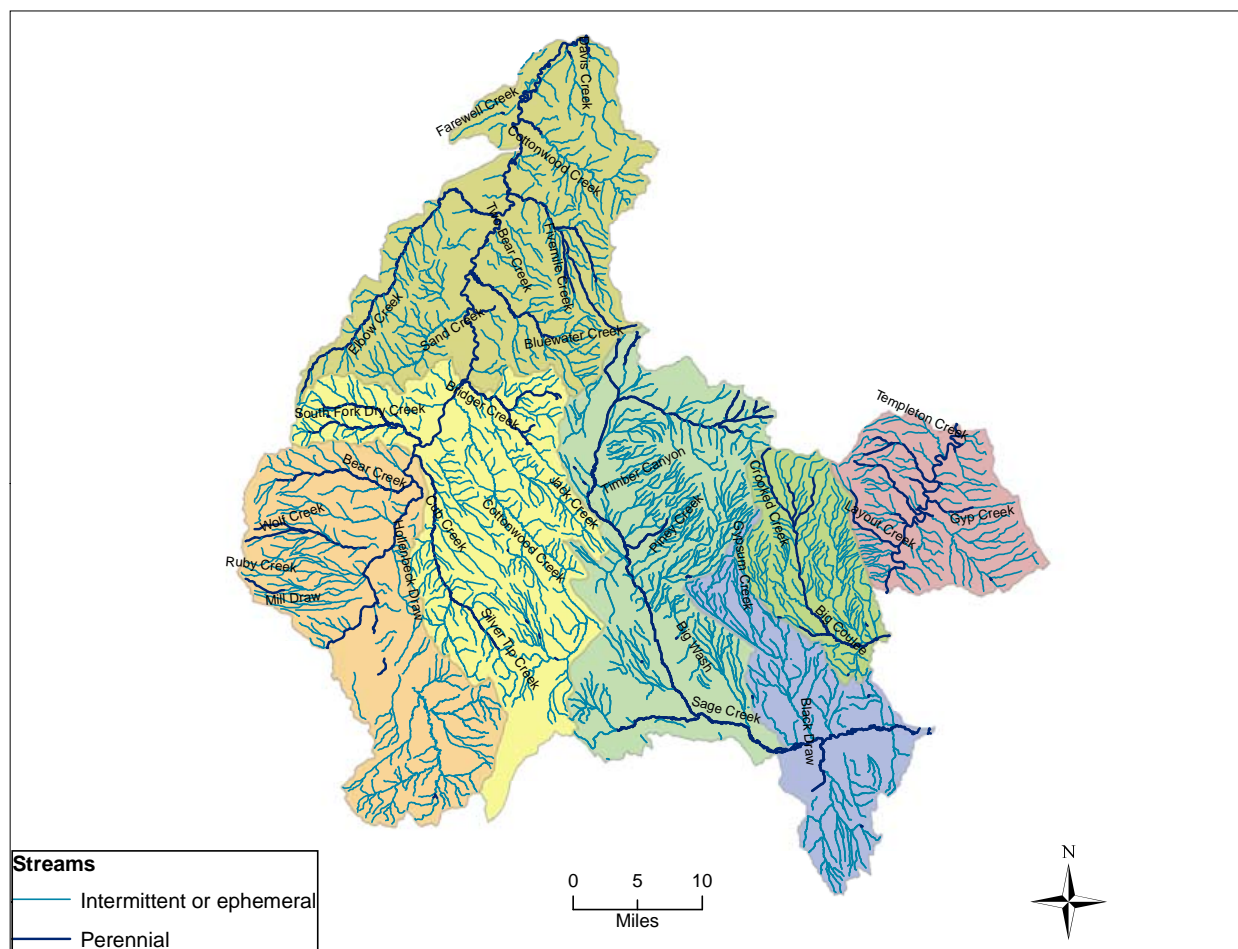


Figure 9. Perennial and intermittent streams.

and rivers, particularly around Sage Creek and in the Elbow Creek watershed. Shrub-Scrub wetlands cover some 36 acres, and forested wetlands another 5 acres. There are approximately 200 acres of constructed wetlands, mostly stock ponds or small reservoirs, in the Montana portion of the study area. Riparian forests are still fairly extensive along the Clark's Fork of the Yellowstone, the Shoshone, and Crooked Creek, although they are heavily infested by Russian olive in the corridors of the first two rivers. There are also several aspen groves near the upper reaches of Grove Creek.

Natural Communities

Vegetation

The dominant vegetation types in the area are sagebrush steppe, wheatgrass-needlegrass grasslands, salt desert scrub, desert scrub and woodlands of

juniper, ponderosa pine and limber pine. Wyoming big sagebrush, black sagebrush (*Artemisia nova*), and in the Bighorn Basin, birdsfoot sage (*Artemisia pedatifida*) are the most common sage species, often codominant with rubber rabbitbrush and shadscale, or with Gardner's saltbush in saline or alkaline sites. Greasewood flats are also common on more alkaline soils. Grasslands contain a mix of native and exotic species. Common native species include western wheatgrass, bluebunch wheatgrass, fescues, needle-and-thread grass, blue grama, Sandberg bluegrass and junegrass. Among the non-natives, smooth brome (*Bromus inermis*) and timothy (*Phleum pratense*) are most common in the moister foothill grasslands. Japanese brome (*B. japonicus*) and cheatgrass (*B. tectorum*) have become widespread. *Astragalus* species, fringed sagewort, and broom snakeweed (*Gutierrezia sarothrae*) are the most frequently-encountered forbs.

Big sagebrush shrubland vegetation overlaps with the juniper (*Juniperus scopularum*) forests found along west-facing drainages. Ponderosa pine grows sparsely on the same aspect. In the Pryors, Douglas-fir and limber pine grow at low elevations on north- and east-facing slopes. Subalpine fir and Douglas-fir dominate the higher forests in the west part of the study area.

Riparian forests within the assessment area are varied. Around the headwaters of Grove Creek, quaking aspen-red osier dogwood (*Populus tremuloides*-*Cornus stolonifera*) forests occur, mixing with forest grasses, sedges, and non-vascular plants. In the foothills and grasslands, riparian forests are primarily cottonwood, with hawthorn more common in the Pryors. Snowberry-rose (*Symphoricarpos albus*-*Rosa woodsii*) dominates the understory, except where it has been removed by grazing. Common forbs include yarrow (*Achillea millefolium*), American vetch (*Vicia americana*), scurfpea (*Psoraleidum tenuiflorum*) and milkweed (*Asclepias speciosa*). In general, the cottonwood forests along the Clark's Fork exhibit fairly good survival and reestablishment, although they are being crowded out by Russian olive in many places. In other areas, notably Cottonwood Creek and Silver Tip Creek, only remnant cottonwoods remain. Salt cedar (*Tamarix ramosissima*, *T. chinensis*, and their hybrids) is well established along the Shoshone River.

One notable feature of the assessment area is the high level of endemism, particularly in the Pryor Mountains. Several vascular plant Species of Concern occur throughout the area (Mincemoyer 2006). These are listed along with vertebrate Species of Concern in Table 1.

Wildlife and Fish

Although much of the assessment area is used for livestock grazing, hay, or crop agriculture, game and non-game wildlife species are common. Small pronghorn (*Antilocapra americana*) herds are found near agricultural areas, while mule deer (*Odocoileus hemionus*) and white-tail deer (*Odocoileus virginianus*) are common in the bottomlands. Elk (*Cervus elephus*), Rocky Mountain bighorn sheep (*Ovis canadensis*) and mountain

goats (*Oreamnos americanus*) are found in more mountainous areas, as are mountain lion (*Felis concolor*), and black bear (*Ursus americanus*). Greater Sage-Grouse (*Centrocercus urophasianus*) can be found throughout the area, particularly in the flats above Crooked Creek. Coyote (*Canis latrans*) are ubiquitous. Black-tail prairie dogs (*Cynomys ludovicianus*) and white-tailed prairie dogs (*Cynomys leucurus*) have both been reported in the assessment area. The extensive cottonwood forests along the Clark's Fork Yellowstone and Shoshone shelter substantial numbers of birds, while bats find attractive habitat in the dissected terrain. Beaver (*Castor canadensis*) and muskrat (*Ondatra zibethicus*) can be found along river bottomlands, particularly in Crooked Creek. Fish species in the area include longnose dace (*Rhinichthys cataractae*), longnose sucker (*Catostomus catostomus*), mountain sucker (*Catostomus platyrhynchus*), white sucker (*Catostomus commersoni*), and the introduced brown trout (*Salmo trutta*) and rainbow trout (*Oncorhynchus mykiss*). Crooked Creek has a population of Yellowstone cutthroat trout (*Oncorhynchus clarkii bouvieri*), a Montana Species of Concern. This is believed to be the eastern extent of the species.

The Human Setting: Prehistory and Early Settlement

The assessment area was once part of the vast territory traversed by the nomadic Crow Indians, who followed the bison herds through the valleys of the Yellowstone, Bighorn, Tongue and Powder Rivers. More concerned with the westward pressure of their sworn enemies, the Sioux, the Crow were generally open to trade and commerce with whites, particularly the mountain men who roamed the Beartooth mountains in search of beaver. In 1851, the Fort Laramie Treaty recognized Crow Territory as extending from the headwaters of the Powder River to the headwaters of the Yellowstone, and north to the Musselshell River. The Crow continued their nomadic ways, exchanging raids with enemy tribes, but generally avoiding conflicts with whites. As the bison herds declined, however, they began negotiating land exchanges with the government, typically receiving cash grants and commitments for agricultural assistance in return. One

Table 1. Species of Concern in the Study Area.

Scientific Name	Common Name	Global Rank	State Rank	BLM Status
Vascular Plants				
<i>Eleocharis rostellata</i>	Beaked Spikerush	G5	S2	
<i>Pyrrocoma carthamoides</i>	Beartooth Large-flowered	G4G5T2T3	S1S2	SENSITIVE
	Goldenweed			
<i>Erigeron formosissimus</i>	Beautiful Fleabane	G5	S1	
<i>Erigeron allocotus</i>	Big Horn Fleabane	G3	S3	
<i>Penstemon caryi</i>	Cary's Beardtongue	G3	S3	
<i>Arabis demissa</i>	Daggett Rockcress	G5	S1	SENSITIVE
<i>Malacothrix torreyi</i>	Desert Dandelion	G4	S1	SENSITIVE
<i>Hemicarpha drummondii</i>	Drummond's Hemicarpha	G4G5	SH	
<i>Mentzelia pumila</i>	Dwarf Mentzelia	G4	S2	SENSITIVE
<i>Astragalus geyeri</i>	Geyer's Milkvetch	G4	S2	SENSITIVE
<i>Epipactis gigantea</i>	Giant Helleborine	G3G4	S2	
<i>Aster glaucodes</i>	Gray Aster	G4G5	S3	
<i>Astragalus grayi</i>	Gray's Milkvetch	G4?	S1S2	SENSITIVE
<i>Hutchinsia procumbens</i>	Hutchinsia	G5	S1	SENSITIVE
<i>Ranunculus jovis</i>	Jove's Buttercup	G4	S2	
<i>Leptodactylon caespitosum</i>	Leptodactylon	G4	S2	SENSITIVE
<i>Lesquerella lesicii</i>	Lesica's Bladderpod	G1	S1	SENSITIVE
<i>Stipa lettermanii</i>	Letterman's Needlegrass	G5	S1	
<i>Cryptantha scoparia</i>	Miner's Candle	G4?	S1	SENSITIVE
<i>Nama densum</i>	Nama	G5	S1	SENSITIVE
<i>Camissonia andina</i>	Obscure Evening-primrose	G4	S1	SENSITIVE
<i>Potentilla plattensis</i>	Platte Cinquefoil	G4	S1	SENSITIVE
<i>Poa curta</i>	Short-leaved Bluegrass	G4	S1	SENSITIVE
<i>Shoshonea pulvinata</i>	Shoshonea	G2G3	S1	SENSITIVE
<i>Kobresia simpliciuscula</i>	Simple Kobresia	G5	S2	SENSITIVE
<i>Camissonia parvula</i>	Small Camissonia	G5	S1	SENSITIVE
<i>Eriogonum salsuginosum</i>	Smooth Buckwheat	G4?	S1	SENSITIVE
<i>Grayia spinosa</i>	Spiny Hopsage	G5	S2	SENSITIVE
<i>Eupatorium maculatum</i>	Spotted Joepye-weed	G5	S1S2	
<i>Asclepias incarnata</i>	Swamp Milkweed	G5	S1	
<i>Astragalus aretioides</i>	Sweetwater Milkvetch	G4	S1	SENSITIVE
<i>Townsendia spathulata</i>	Sword Townsendia	G3	S3	
<i>Astragalus oreganus</i>	Wind River Milkvetch	G4?	S1	SENSITIVE
<i>Sullivantia hapemanii</i>	Wyoming Sullivantia	G3	S2	SENSITIVE
<i>Cleome lutea</i>	Yellow Bee Plant	G5	S1	SENSITIVE
Vertebrates				
<i>Ammodramus bairdii</i>	Baird's Sparrow	G4	S2B	SENSITIVE
<i>Haliaeetus leucocephalus</i>	Bald Eagle	G5	S3	SPECIAL STATUS

Table 1. Continued.

Scientific Name	Common Name	Global Rank	State Rank	BLM Status
Vertebrates				
<i>Tyto alba</i>	Barn Owl	G5	S1	
<i>Cynomys ludovicianus</i>	Black-tailed Prairie Dog	G4	S3	SENSITIVE
<i>Poliophtila caerulea</i>	Blue-gray Gnatcatcher	G5	S1B	SENSITIVE
<i>Dolichonyx oryzivorus</i>	Bobolink	G5	S2B	
<i>Spizella breweri</i>	Brewer's Sparrow	G5	S2B	SENSITIVE
<i>Selasphorus platycercus</i>	Broad-tailed Hummingbird	G5	S1B	
<i>Athene cunicularia</i>	Burrowing Owl	G4	S2B	SENSITIVE
<i>Lynx canadensis</i>	Canada Lynx	G5	S3	SPECIAL STATUS
<i>Calcarius ornatus</i>	Chestnut-collared Longspur	G5	S3B	SENSITIVE
<i>Sceloporus graciosus</i>	Common Sagebrush Lizard	G5	S3	
<i>Myotis thysanodes</i>	Fringed Myotis	G4G5	S3	SENSITIVE
<i>Canis lupus</i>	Gray Wolf	G4	S3	SPECIAL STATUS
<i>Centrocercus urophasianus</i>	Greater Sage-Grouse	G4	S3	SENSITIVE
<i>Phrynosoma hernandesi</i>	Greater Short-horned Lizard	G5	S3	SENSITIVE
<i>Ursus arctos</i>	Grizzly Bear	G4	S2S3	SPECIAL STATUS
<i>Histrionicus histrionicus</i>	Harlequin Duck	G4	S2B	SENSITIVE
<i>Calamospiza melanocorys</i>	Lark Bunting	G5	S3B	
<i>Lanius ludovicianus</i>	Loggerhead Shrike	G4	S3B	SENSITIVE
<i>Numenius americanus</i>	Long-billed Curlew	G5	S2B	SENSITIVE
<i>Sorex merriami</i>	Merriam's Shrew	G5	S3	
<i>Lampropeltis triangulum</i>	Milksnake	G5	S2	SENSITIVE
<i>Charadrius montanus</i>	Mountain Plover	G2	S2B	SENSITIVE
<i>Accipiter gentilis</i>	Northern Goshawk	G5	S3	SENSITIVE
<i>Antrozous pallidus</i>	Pallid Bat	G5	S2	SENSITIVE
<i>Falco peregrinus</i>	Peregrine Falcon	G4	S2B	SENSITIVE
<i>Spea bombifrons</i>	Plains Spadefoot	G5	S3	SENSITIVE
<i>Oreoscoptes montanus</i>	Sage Thrasher	G5	S3B	SENSITIVE
<i>Sander canadensis</i>	Sauger	G5	S2	SENSITIVE
<i>Apalone spinifera</i>	Spiny Softshell	G5	S3	SENSITIVE
<i>Euderma maculatum</i>	Spotted Bat	G4	S2	SENSITIVE
<i>Corynorhinus townsendii</i>	Townsend's Big-eared Bat	G4	S2	SENSITIVE
<i>Spilogale gracilis</i>	Western Spotted Skunk	G5	S1S3	SENSITIVE
<i>Cynomys leucurus</i>	White-tailed Prairie Dog	G4	S1	SENSITIVE
<i>Gulo gulo</i>	Wolverine	G4	S3	SENSITIVE
<i>Oncorhynchus clarkii bouvieri</i>	Yellowstone Cutthroat Trout	G4T2	S2	SENSITIVE

of these negotiations led to the Treaty of 1868, in which the Crow ceded a portion of their territory in return for all the land from the Yellowstone River to the Wyoming Border, and east to the divide between the Big Horn and Rosebud rivers. However, white miners and ranchers soon began eyeing the mineral-rich mountain areas and the fertile valley bottoms of the Yellowstone and its major tributaries (Hamilton 1957). After a series of botched negotiations, treaties and attempts to relocate the Crow to the Judith Basin, an 1880 agreement led to the Crow ceding a final 2,000,000 additional acres on the west of their reserved lands, accepting annuities and additional agricultural support in return.

With the Crow lands released, white settlement began in earnest. Coal had been discovered in the area in the 1860s, but the Crow retreat allowed the Northern Pacific Railroad to expand its lines, providing the infrastructure that allowed transport of coal. Within a few years, the mining boom began. The discovery of high-grade coal in Red Lodge in the mid-1880s led to more railroad building and the formation of coal extraction companies, first in Red Lodge and then in nearby Washoe and Bear Creek. Abundant employment opportunities and the offer of 160-acre homesteads brought settlers into the area, mostly from northern Europe. In 1915, the

discovery of oil and gas in nearby Elk Basin accelerated development of the region.

For almost 50 years, resource extraction drove the area economy. But labor strife, fluctuating demand, and the depression all took a toll on mining. In 1943, an explosion at the Smith Mine in Bearcreek killed 74 miners, and led to the collapse of the coal mining industry in the region. Agriculture soon became the mainstay of the local economy. Although the town of Red Lodge (outside the study area) has reinvented itself as a tourist destination, Bear Creek and Washoe are almost ghost towns.

Carbon County is primarily agricultural. In the 2002 census of agriculture, Carbon County listed a total of 584 farms covering over 2,811,000 acres, with 54,496 acres irrigated. Almost 400,000 acres are in cropland, with small grains (barley, wheat and oats), corn, sugar beets, and hay the main crops. In the county as a whole, 399 farms reported raising cattle. The portions of Big Horn County and Yellowstone County lying within the study area are similarly dominated by agriculture, with grazing in the foothills and crops on the valley floor. Wyoming portions of the study area have a higher population density, but agriculture is still the major land use.

METHODS

Broad-scale Remote Sensing Analysis

For this analysis, we have used a broad-scale landscape assessment approach developed in prior watershed studies (Vance et al. 2006, Vance and Stagliano 2007) to provide a landscape perspective on the natural diversity, current conditions, and potential threats to wetland and riparian habitats. We began by separating the assessment area into component landscape units so effective comparisons could be made between units. Based on topography, land cover, and field observations, we decided to analyze the landscape by individual 5th code hydrologic units (HUCs). We calculated a number of metrics to allow overall comparisons and provide managers with a basis for planning. For certain metrics, we extended the analysis to 6th code HUCs. In all cases, HUC boundaries were taken from U.S. Geological Survey maps.

We conducted a GIS analysis using geographic and statistical data to summarize potential and actual watershed condition, and to compare watershed conditions and threats among the landscape units. The analysis was divided into three parts. The first part assessed “background” or natural conditions in the watershed by evaluating ecological diversity and hydrologic and topographic complexity. The second part addressed current conditions and disturbances, including land use, ownership patterns, and alterations and impacts to riparian areas. The third part focused on three threats to watershed integrity: riparian grazing, residential development and oil and gas extraction. In the natural condition assessment, we compared all watersheds within the area. In the current condition and threat assessments, we were only able to complete the analysis for Montana portions of the area. Wyoming does not maintain digital databases of cadastral data, so information on land ownership was not available for metric calculation. However, we did calculate land use metrics from national datasets.

In each part, indices were created or used to facilitate comparison between watersheds. This

index-based approach follows a method initially developed by the Northeast Region of the National Wetland Inventory Program (Tiner et al. 2000), modified and expanded by the Montana Natural Heritage Program (Vance 2005, Vance et al. 2006) to address some of the unique conditions in western ecosystems (e.g. grazing impacts, energy development, etc). This methodology is explained in greater detail in subsequent sections.

National Wetland Inventory photointerpretations dating from the 1980s were never digitized or turned into hard-copy maps for this area. The Montana Natural Heritage Program is currently producing wetland and riparian maps for Southeastern Montana, but maps for this area have not been subject to a QA/QC process and are not yet official. While we refer to them in this study, we have not made a final assessment of the number, acreage or types of wetlands affected by land use impacts or other stressors. During field season, we had no wetland maps available, and so used high-resolution National Hydrography Dataset maps and aerial photographs to identify some open water wetlands for field assessment.

The geographic data used in the assessment and in calculating the sub-indices were derived as follows:

1. Natural Complexity Index

a) Hydrologic Complexity Index

- Using the high-resolution National Hydrography Dataset, identify springs, intermittent and perennial streams, and intermittent and perennial lakes, and sum the number and length/area, as appropriate, for each category.

b) Topographic Complexity Index

- Create a topography polygon layer by reclassifying 10-meter USGS Digital Elevation Maps into 25 elevation classes, and sum acreage in each elevation class.

c) Ecological Diversity Index

- From ReGAP maps, calculate the diversity of ecological systems in each 5th code HUC.

2. Composite Wetland Condition Index

a) Natural Cover Index

- Weight the land cover categories within the watershed boundaries from the 2001 USGS National Land Cover Dataset to separate them into human, natural classes, and semi-natural classes (e.g. grazed grasslands, hayfields).

b) Stream Corridor Integrity Index

- Buffer stream segments in the 1:100,000 USGS National Hydrography Dataset streams layer;
- Overlay the buffered stream segments on the 2001 National Land Cover Dataset;
- Sum the acreage of land cover categories within the buffered areas.

c) Riparian Loss Index

- Buffer stream segments in the 1:100,000 USGS National Hydrography Dataset streams layer;
- Sum the acreage of tree cover, shrub cover and woody wetland cover within the riparian buffer, based on the 2001 National Land Cover Dataset;
- Calculate the difference in acreage between the summed riparian cover and a hypothetical 30% woody riparian cover.

d) Road Disturbance Index

- Measure road density (total road length per areal unit of HUC);
- Calculate number of road crossings per mile of stream/river length.

3. Composite Riparian Threat Index

a) Oil and gas Threat Index

- Calculate the acreage of land covered by oil and gas leases in each 5th code HUC.

b) Residential Development Threat Index

- Buffer all roads by 1 mile;
- Identify privately-owned parcels greater than 10 acres in size within the buffer not used for crops or other irrigated agriculture;
- Calculate the average parcel size within each 5th code HUC;
- Count the number of existing parcels 20 acres or smaller in each 5th code HUC.

c) Riparian Grazing Threat Index

- Create a layer of private grazing lands from cadastral records (parcels listed as having grazing as their major land use);
- Create a layer of public grazing lands from cadastral records (parcels listed as having BLM, Forest Service, Montana Fish, Wildlife and Parks or the Montana Department of Natural Resources as the owner);
- Overlay the public and private grazing lands layer on the buffered stream layer.

Field Data Collection and Assessment

During the summer of 2007, MTNHP ecologists carried out Proper Functioning Condition (PFC) assessments at 73 sites, using the methods described in Pritchard et al. (1999), supplemented with MTNHP rapid assessment protocols. Thirty-six of these sites involved resampling of sites last assessed in 2005 (Figure 10). Photos were taken at every site. During all phases of data collection, wetlands were classified with the National Wetland Inventory (NWI) system (Cowardin et al. 1979).

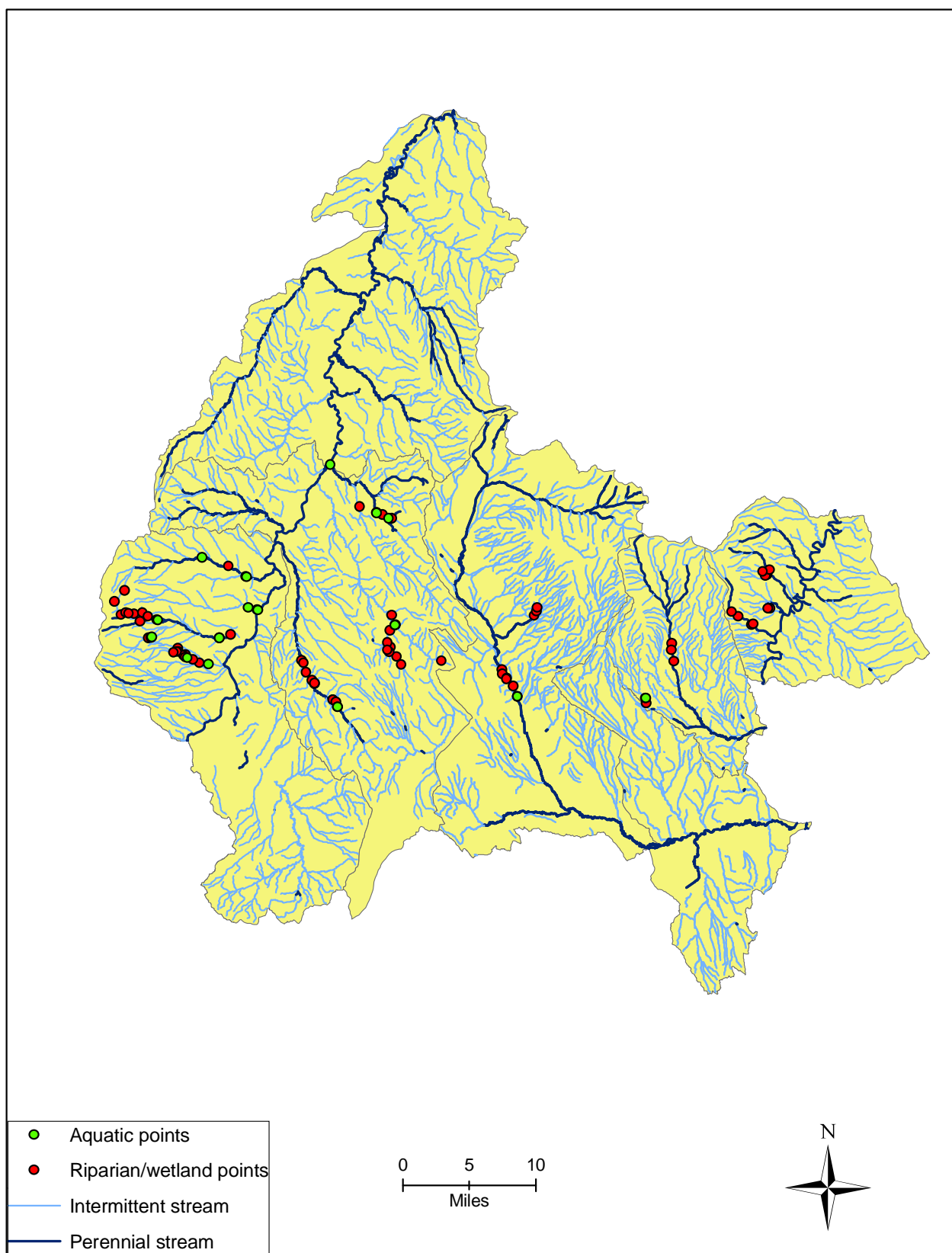


Figure 10. PFC and aquatic survey sites.

For both wetland and upland plants, our principle floristic references were Dorn (1984) and the Great Plains Flora (1977, 1986). All plant nomenclature follows Kartesz (1999). We analyzed our vegetation data to identify plant associations consistent with the National Vegetation Classification System (NVCS, Grossman et al. 1998). This is a hierarchical system combining floristics at the lowest levels (associations and alliances) and physiognomy and climate at the highest levels. Plant associations are defined by the dominant species in the uppermost

vegetation layer and any co-dominant species, diagnostic species, or the dominant species of understory vegetation layers.

Riparian habitat assessments, water quality parameter measurements, fish and macroinvertebrate surveys were performed at 13 sites. Biological community integrity was calculated at all sites using Fish Integrated Biotic Indices (IBI's) and Observed/Expected Models (O/E), as well as macroinvertebrate multi-metrics (MT MMI).

RESULTS AND DISCUSSION

Broad-scale Assessment

Current Conditions

Across the Montana portion of the assessment area, the BLM owns or manages approximately 217,000 acres, or 25% of the land (Figure 11). Nine percent of the Montana assessment area is owned by the US Forest Service and managed by the Beartooth Ranger District. Approximately 3% is in the Big-horn Canyon National Recreation Area, and an additional 3% is State Trust Land. The Crow Indian Reservation comprises about 11% of the area. By ecoregion, BLM ownership is highest in the Big-horn Basin and the Mid-Elevation Sedimentary Mountains, and lowest in the Central Grasslands. The BLM manages three special status areas: the 21,000 acre Wild Horse Range (which includes a 20,000+ acre Wilderness Study area in the Crooked

Creek watershed) and the 900 acre Meeteetse Spires Area of Critical Environmental Concern.

The Forest Service manages two special status areas: the Lost Water Canyon Research Natural Area, also in the Crooked Creek watershed, and the Line Creek Plateau Research Natural Area, not far from the Meeteetse Spires. Just under 50% of the land is privately owned. Most of the private land lies within the Clark's Fork Yellowstone-Silver Tip Creek and Clark's Fork Yellowstone-Elbow Creek watersheds.

Across the assessment area as a whole, 50% of the land cover is shrubland, 32% is grassland, and 6% is forest. Wetlands make up less than 2% of the landcover. Pasture and cropland account for 9%. (Figure 12). Both public and private grasslands and shrublands are used primarily for cattle grazing.

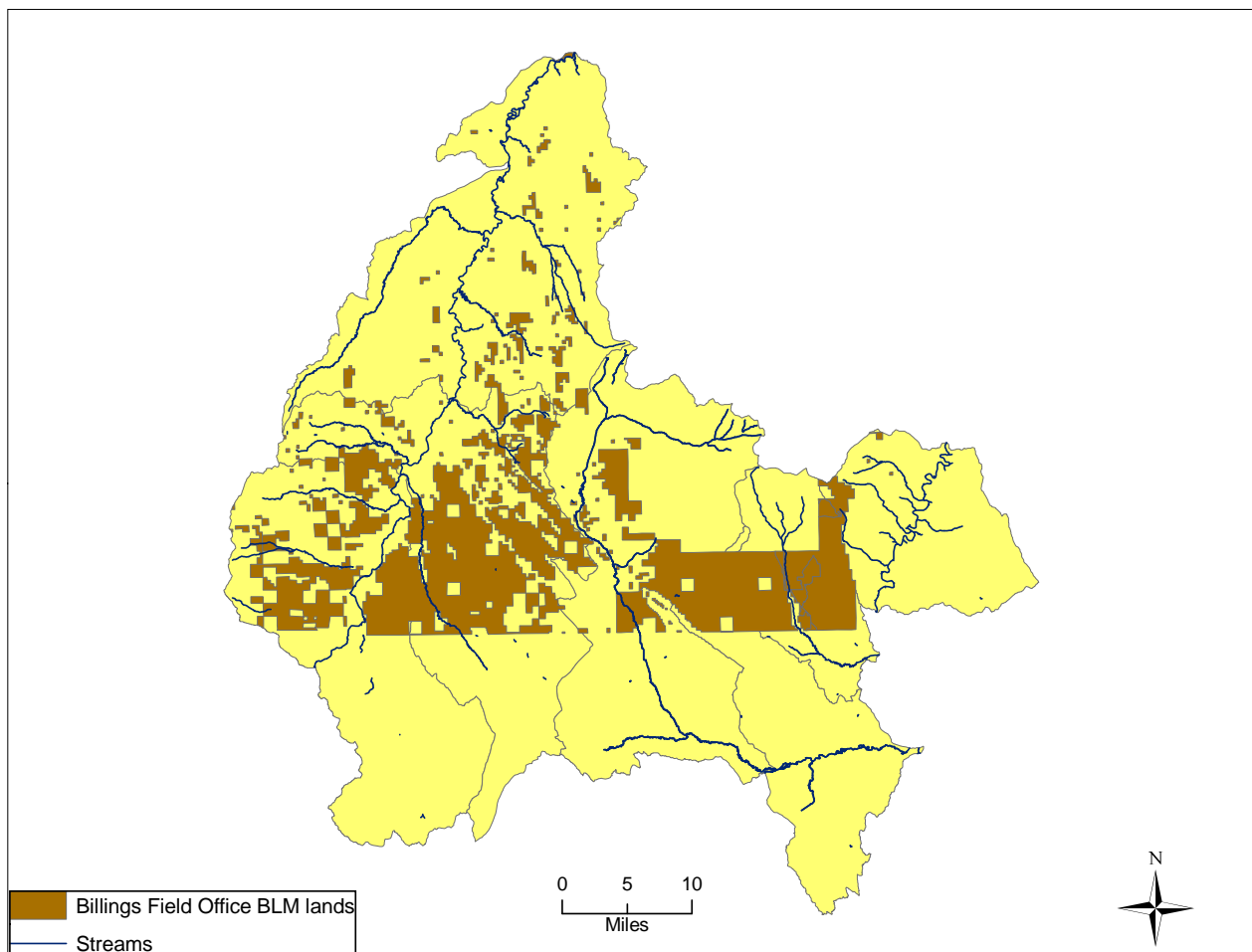


Figure 11. Billings Field Office BLM administered lands.

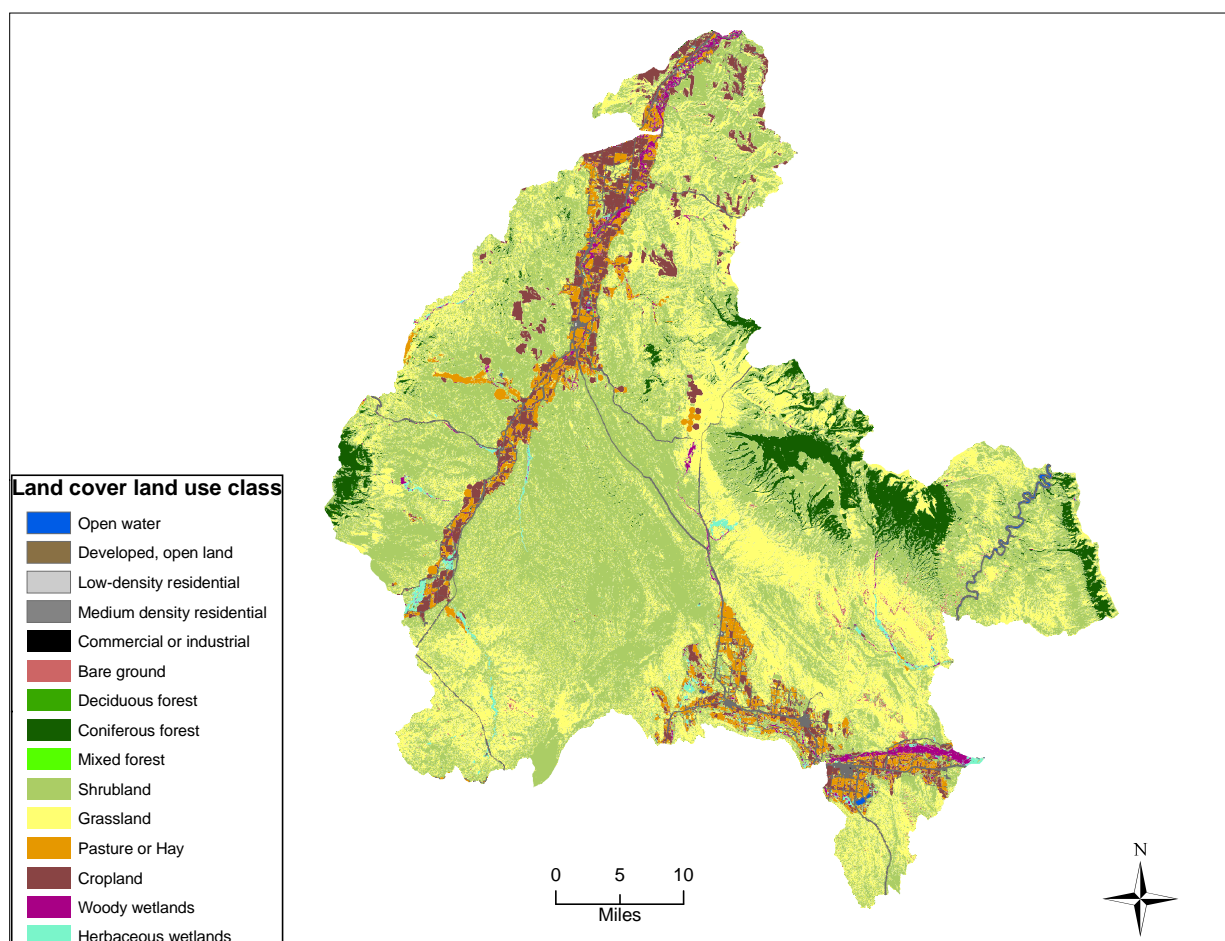


Figure 12. Land cover and land use.

Figure 13 shows the extent of grazing use within the Montana portion of the assessment area. Private parcels listed in the cadastral records as having more than 50% of their acreage in grazing are designated “Private Grazing Lands.” Because most BLM and state lands are leased for grazing, non-forested portions of those lands are designated as “Public Grazing Lands.”

The assessment area encompasses 1,248,264 acres, of which less than 4,870 acres are in lakes, ponds or other water bodies, mostly manmade. There are 616 miles of perennial streams and rivers, and 3,512 miles of intermittent streams. Most of these intermittent streams are in fact ephemeral, flowing only in response to heavy rain events.

Factors and Magnitude of Change

Since Euro-american settlement began, four human activities have had significant impacts on water-

shed health and integrity in this part of Montana: extraction, diversion and impoundment of water; conversion of grasslands to agriculture; livestock grazing; and oil and gas extraction. Associated impacts such as road-building, and secondary impacts, such as low-intensity residential development, have also altered natural conditions.

Extraction, Diversion and Impoundment of Water

Flows in the Clark’s Fork, Shoshone and Bighorn rivers are moderated by major upstream and downstream impoundments, and influxes from tributary rivers are reduced by diversion and impoundment. Nonetheless, flows prior to irrigation season are sufficient to maintain a more-or-less natural hydrologic regime, with floods and peak flows occurring at regular intervals. During the spring of 2007, flushing flows and minor flooding were observed in several tributaries.

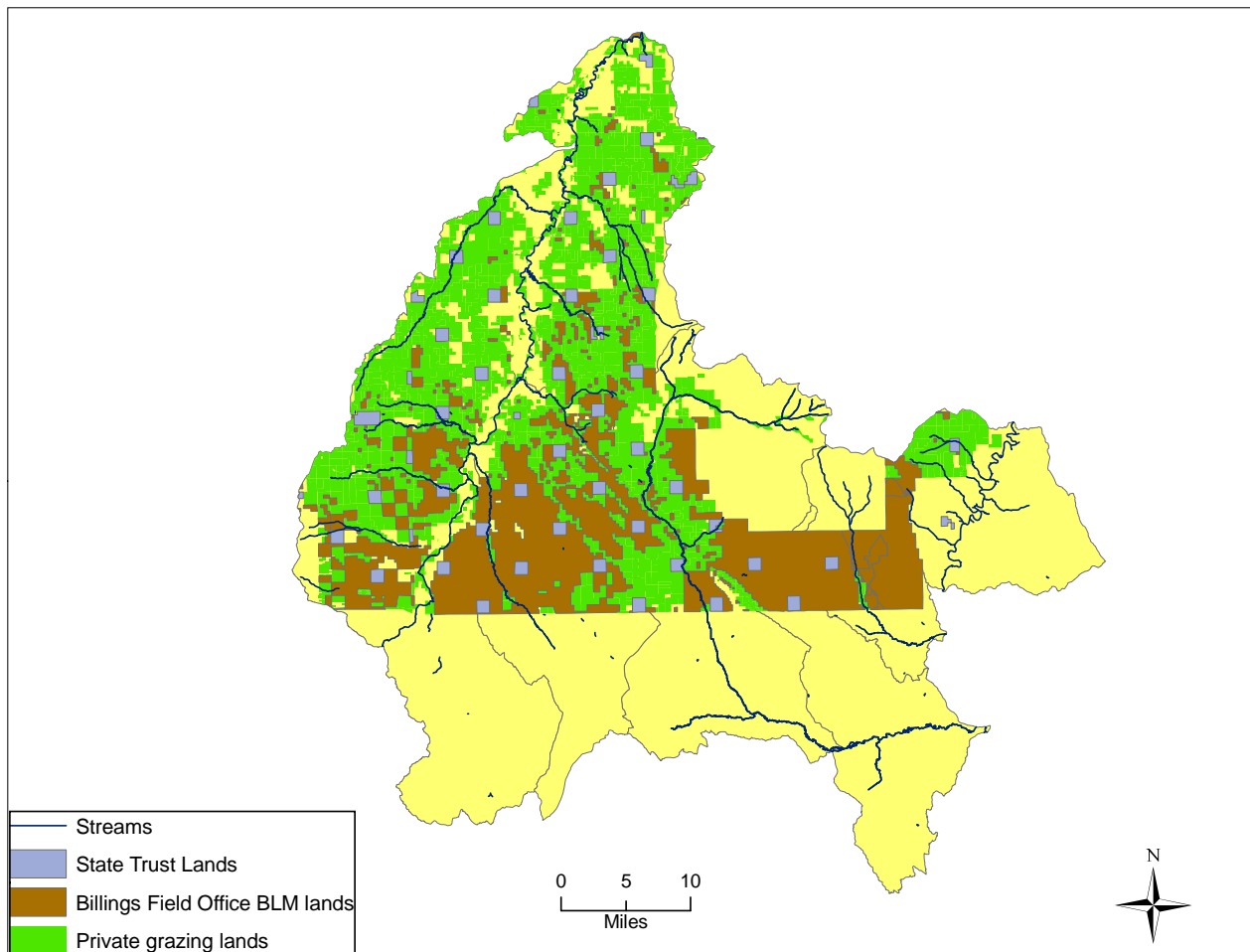


Figure 13. Public and private grazing lands, Montana

Across the assessment area, small dams, diversions and impoundments on headwater and mainstem streams tend to minimize temporal variability in stream flows. By eliminating flood peaks, these dams, diversions and impoundments lead to narrowing and firming of channel beds over time, and to the loss of bare substrate on streambanks necessary for successful regeneration of woody vegetation. Streams in the assessment area have also downcut significantly over time, and in most areas, only remnant (and decadent) cottonwoods remain. In the Montana portion of the assessment area (the only part for which water rights records are readily available), there are currently 317 reservoirs ranging in size from 500 acres to less than 1 acre, 153 surface water diversions (dams, ditches, headgates, etc.) and 228 ground water diversions. Silver Tip Creek has the highest number of diversions, at 114, followed by Elbow Creek with 99. Fifty-nine percent of the points of use list irrigation as

their primary purpose, 22% list stockwatering, and the remainder cover a variety of uses that include recreation, fisheries, domestic use, erosion control, and mining.

None of the rivers or streams in the assessment area have been evaluated by the Montana Department of Environmental Quality as part of the TMDL process (MTDEQ 2007).

Conversion of Grasslands to Agriculture

Grassland conversion can affect watershed health and integrity in a number of ways: first, it is generally accompanied by water withdrawal for agricultural use; second, it eliminates or impedes regrowth of native vegetation while facilitating invasion by weedy species; and third, erosion from tillage and farm roads contributes to increased sedimentation of streams and rivers (Power et al. 1995). In the assessment area, agricultural conversion is relatively

low. Grasslands account for approximately 32% of the land cover, pasture and haylands for 4%, and row crop, small grain, or fallowed fields for 4.7%.

Most of the land identified as grassland on National Land Cover Dataset maps is privately owned, and is used for grazing. While this is not strictly a conversion, both grazing and crop production put heavy demands on water supplied by wells and surface water diversions. Agricultural conversion also puts aquatic resources at risk through increased erosion and sedimentation, while overgrazing can lead to invasion of grasslands by non-native plant species. During our field surveys, we observed widespread cheatgrass (*Bromus tectorum*) in overgrazed grassland areas (Figure 14).



Figure 14. Cheatgrass in Weatherman Draw.

Livestock grazing

As noted earlier, livestock grazing is the dominant agricultural use in the assessment area. Cattle are the most common grazing animals, although sheep are still present in small numbers, and feral horses roam the Bighorn River-Layout Creek watershed. Although the Great Plains ecosystems evolved under grazing pressures from hooved ungulates, the seasonality and intensity of bison and elk grazing differ from current systems. If not managed optimally or effectively, cattle and sheep grazing can cause soil compaction, nutrient enrichment, vegetation trampling and removal, habitat disturbance, and, depending on the season and intensity of use,

reproductive failure for native plants and animals. Grazing in riparian areas can cause stream and river bank destabilization, loss of riparian shade, and increased sediment and nutrient loads in the aquatic ecosystem (George et al. 2002). Stock watering tanks can contribute to dewatering of streams and aquifers, and may concentrate livestock movement and congregation in sensitive areas. During hot summers, cattle and sheep prefer to loaf in shady areas, trampling understory vegetation.

In our field surveys, we saw widespread evidence of improper grazing or substantial degradation of aquatic resources by livestock. In many of the Bear Creek watershed streams, riparian vegetation had been removed or trampled by cattle, who shaded up under the remaining trees (Figure 15). Springs and seeps were also heavily impacted in that watershed. While we saw individual instances of fencing and exclusion, most of the aquatic resources were unprotected.



Figure 15. Loss of riparian understory, Bear Creek watershed.

Broad-Scale Assessment Indices

In previous watershed assessments (Crowe and Kudray 2003, Vance 2005, Vance et al. 2006), the Montana Natural Heritage Program developed a method for broad-scale assessment of wetlands based on a procedure originally developed by the Northeast Region of the U.S. Fish and Wildlife Service National Wetland Inventory Program (Tiner et al. 2000). We have continued to refine this method by adding new metrics, dropping redundant or insensitive metrics, and refining scoring for land use categories. We believe these ongoing refinements provide a better baseline for assessment, and more accurately evaluate the stressors found in western watersheds.

This assessment procedure has three components. First, we generated a Composite Natural Complexity Index, based on underlying vegetation, hydrologic and elevation factors, to capture the extent and variation of natural conditions within the overall assessment area and the individual watersheds. Each of the sub-indices is scaled from 0.0 to 1.0, with higher scores reflecting greater complexity.²

Next, we used two sub-indices of habitat extent and two sub-indices of disturbance to produce the overall Composite Watershed Condition Index (CWCI). This index gives a sense of how much pre-settlement habitat remains in the assessment area watersheds, emphasizing riparian systems and adjacent upland habitat, i.e. buffers. In this step, higher scores on the habitat sub-indices represent more optimal conditions, while higher scores on the disturbance sub-indices indicate potential problems. The habitat indices are added together and the disturbance indices are subtracted from this sum to create the Composite Watershed Condition Index (CWCI) for each 5th code HUC.

In the final step, we calculated a Composite Wetland Threat Index. Because oil and gas extraction, residential development and grazing all have the potential to degrade wetlands and riparian areas

over time, we have designated them as ongoing and/or future threats. Here, higher scores signal a higher level of threat.

One criticism of indices of biological integrity is individual characteristics of the system being assessed are blurred by the act of collapsing multiple metrics into a single number (Moyle et al. 1999). To offset this danger, we have chosen to keep the three overall indices distinct from one another. This way, characteristics of each watershed can be compared without significantly diminishing the magnitude of specific disturbances or threats.

Composite Natural Complexity Index

In past assessments, we have used *diversity indices* to characterize the inherent natural features of the watersheds, reasoning that these underlying factors can influence both overall condition and the severity of threats. Diversity indices are mathematical measurements of community composition, typically used to assess species diversity, although they are sometimes used at the landscape level (Rosenzweig 1995). Here, we depart from that practice in favor of a “Natural Complexity Index,” which we feel captures the variability inherent in the assessment area without complex mathematical analysis. The Natural Complexity Index measures the richness and extent of vegetation, hydrologic features and topography. It has three subindices, the Natural Community Complexity Index, the Hydrologic Complexity Index and the Topographic Complexity Index, explained below.

Natural Community Complexity Index (I_{NC})

The Natural Community Complexity Index is a simple measure of the number of ecological systems in individual watersheds relative to the total number of ecological systems across the study area. Ecological systems are defined as groups of plant community types that tend to co-occur within areas having similar ecological processes, substrates, and/or environmental gradients (Comer et al. 2003). Spatially, ecological systems occur at

² In earlier assessments, we were also able to evaluate wetland diversity as part of this index; in this assessment area, wetland mapping was not complete by the time of this report, so this part of the assessment could not be performed. However, our field surveys indicated there is very little wetland diversity in these watersheds, and indeed, very few natural wetlands. Moreover, the wetlands that do exist - particularly around Sage Creek - have been degraded by multiple stressors, and are severely infested with noxious weeds.

the scale of less than a acre to tens of thousands of acres; temporally, they persist for 50 to 150 years. This temporal scale allows typical successional dynamics to be integrated into the concept of each ecological system. Because individual ecological systems themselves may contain multiple community types, system richness is a good indicator of complexity.³ There are 43 different natural ecological systems in the assessment area as a whole. Natural community complexity was calculated by dividing the number of ecological systems in each 5th code HUC by the number of systems in the assessment area. The results were converted to an ordinal scale by dividing all scores by the highest score.

The Crooked Creek and Sage Creek watersheds had the highest Natural Community Complexity scores, indicating they have the greatest ecological diversity (Table 2). Both these watersheds are in the Mid-Elevation Sedimentary Mountains ecological subsection, where there are numerous springs and seeps, forests, and a high level of endemism. The Silver Tip watershed, in the Bighorn Basin ecological subsection, scored lowest. It is primarily sage-dominated, with relatively little variation in climate or substrate.

Table 2. *Natural Community Complexity Index.*

Crooked Creek	1.00
Sage Creek	0.97
Dry Creek	0.82
Elbow Creek	0.82
Bear Creek	0.82
Bighorn River	0.76
Silver Tip Creek	0.61

Hydrologic Complexity Index (I_{HC})

The Hydrologic Complexity Index describes the number and density of hydrologic features in a watershed (springs, seeps, perennial lakes and streams, and intermittent lakes and streams). By characterizing the number and extent of these features, this subindex allows managers to prioritize

watersheds for management efforts or further assessment. Although many of the lakes and ponds are manmade, we have included them in the analysis because they provide significant habitat when managed for those values.

We calculated this index by summing; 1) the number of springs and seeps; 2) the number of lakes, ponds and reservoirs per hundred square miles of watershed; 3) the number of wetlands per 100 square miles of watershed; 4) the density of perennial streams (in miles of stream per square miles of watershed); 5) and the density of intermittent streams (in miles of stream per square miles of watershed). Each of the 7 watersheds received a rank of 1-7 in each category (springs, lake density, wetland density, perennial stream density and intermittent stream density). Low scores in a category meant the watershed had the lowest density of the feature in question. Scores were summed across the categories, and averaged for each watershed. This was then relativized by taking the highest score, and dividing all other scores by that score.

Based on this analysis, the Sage Creek watershed has the most Hydrologic Complexity while the Bighorn River-Layout Creek watershed has the least. Sage Creek has a large number of springs, reservoirs and ponds, and has both perennial streams and wetlands. Bighorn River-Layout Creek, by contrast, has few ponds, reservoirs or wetlands, although it does have a fairly high number of springs. It is worth noting here that this index says nothing about the condition of the hydrologic features. In our field surveys, we noted many of the Sage Creek streams and wetlands were degraded, while the springs in the Bighorn River-Layout Creek watershed were generally in good condition. Table 3 shows the individual scores on this metric.

Topographic Complexity Index (I_{TC})

Topography influences plant community composition and habitat availability for animal populations. The more topographic diversity within a watershed, the more niche habitat and microhabitat available, and the higher the likelihood of rare species while

³ It is possible that ecological systems richness is a function of patchiness resulting from human land uses. However, in the assessment area, our field observations led us to conclude that this was not the case, but rather that ecological system richness did in fact reflect more natural conditions.

Table 3. Hydrologic Complexity Index.

Sage Creek	1.00
Bear Creek	0.87
Dry Creek	0.87
Elbow Creek	0.87
Crooked Creek	0.78
Silver Tip Creek	0.78
Bighorn River	0.57

still ensuring broad representation of species found across the watershed as a whole.

Elevations in the assessment area range from 988 to 2879 meters (3241 to 9,446 feet) above sea level. The Topographic Complexity score was calculated by using a GIS to create 25 equal elevation bands across the assessment area. We summed the number of elevation bands in each watershed, took the log of that sum, and relativized the scores by dividing each log score by the highest log score. Table 4 shows the scores on this metric. The Bear Creek watershed, which extends from the Pryor Mountains to the lowest part of the Clark's Fork Yellowstone valley, has the highest Topographic Complexity score, while the Silver Tip watershed has the lowest.

Table 4. Topographic Complexity Index.

Bear Creek	1.00
Dry Creek	0.99
Bighorn River	0.99
Crooked Creek	0.99
Sage Creek	0.97
Elbow Creek	0.89
Silver Tip Creek	0.81

Composite Natural Complexity Index (CNCI)

We combined the three sub-indices into a Composite Natural Complexity Index. This index has a maximum possible score of 3.00, which would mean the watershed score highest on all three complexity metrics. Table 5 shows the scores on this composite index. As the scores indicate, the Sage Creek 5th code HUC has the highest Composite Natural Complexity within the assessment area watersheds, while the Silver Tip 5th code HUC - which

Table 5. Composite Natural Complexity Index.

Sage Creek	2.94
Crooked Creek	2.77
Bear Creek Creek	2.69
Dry Creek	2.67
Elbow Creek	2.58
Bighorn River	2.31
Silver Tip Creek	2.20

had the lowest scores on all the individual indices - has the lowest.

Again, this is a metric of complexity, not condition. The Bighorn River-Layout Creek watershed, which ranked only a little higher than the Silver Tip watershed, has some of the lowest scores on the disturbance indices (see below) and is home to many plant and animal Species of Concern (Figure 16). However, it is more uniform in terms of vegetation and topography, and lacks the stream density or wetland presence that would represent a higher overall natural complexity.



Figure 16. *Sullivania hapemanii*, a Montana species of concern, in Layout Creek.

Composite Watershed Condition Index

The Composite Watershed Condition Index is made up of four sub-indices. Two habitat extent indices measure the degree to which the watersheds in the assessment area retain the natural conditions believed to have existed prior to Euro-American settlement: the Natural Cover Index and the Stream Corridor Integrity Index. Each of these indices has a score between 0 and 1, with 0 representing the greatest departure from natural conditions, and 1 representing the least departure. These indices are complemented by two disturbance indices that assess the extent of alterations and other disturbances affecting watershed condition: the Riparian Loss Index and the Road Disturbance Index. Each of these indices also has a score between 0 and 1, with 0 representing the lowest level of disturbance and 1 the highest. To arrive at an overall determination of wetland condition, we summed the two condition sub-indices and then subtracted the summed disturbance sub-indices.

Habitat Extent Indices

Natural Cover Index (I_{NC})

The Natural Cover Index measures the ratio of grassland, forest, shrubland, and wetlands/lakes to the total land area in the watershed. Because human activities in watersheds can have far-reaching effects on wetland hydrology, water quality, vegetation, soil development, and nutrient cycling at both the site and watershed scale, more land in natural cover within a watershed can be taken as a positive indicator of overall condition. Inversely, a low score can be interpreted as an indication of the amount of area in a given watershed that is contributing to negative changes in wetland function.

The Natural Cover Index was initially developed for use in the Northeast, where livestock grazing is not as widespread, and consequently it does not account for the impacts of grazing on natural cover. Although grasslands in the western U.S. evolved under grazing regimes, the brief, intense grazing patterns characteristic of bison and elk are not reproduced by cattle, and plant community composition can shift radically under continued,

season-long grazing, especially if cattle are stocked heavily. The original Natural Cover Index also does not distinguish between non-natural land use categories; for example, a watershed with 75% of its land in natural cover and 25% in dry-farmed agriculture would receive the same score as a watershed with 75% of its land in natural cover and 25% in high-intensity residential and commercial development. Therefore, we used a weighting system based on the methodology developed by Hauer et al. (2001, 2002) for field-based landscape assessments, adapting that methodology to the analysis of 2001 National Landcover (NLCD) data sets. In this system, land uses derived from the NLCD are weighted as follows:

Use	Weight
Other	0.5
Open Water	1.0
Low intensity residential	0.3
Commercial, industrial, transportation	0.0
Bare rock, sand or clay	1.0
Deciduous forest	1.0
Evergreen forest	1.0
Mixed forest	1.0
Shrubland	1.0
Grassland or herbaceous	0.7
Pasture or hay	0.6
Cultivated crops/Fallowed land	0.2
Developed, open space	0.4
Herbaceous wetlands	1.0
Woody wetlands	1.0

In this weighting system, all grasslands are assumed to be grazed. Hauer et al. (2001) assigned weights from 0.2 to 0.7 to grazing depending on intensity, but this was not possible from remotely-sensed data. Instead, we assumed that spread across all grasslands, grazing could be weighted as “light,” or 0.7, since some grasslands would only be grazed sporadically. In general, our field observations confirmed grazing in most of the area was indeed light.

The Natural Cover Index is then calculated as:

$$I_{NC} = A_{LCWt} / A_w$$

where A_{LCWt} = sum of the weighted scores for land

cover in acres, and A_w = total area in the watershed. For the assessment area as a whole, the score is 0.84. Scores for the individual watersheds are shown in Table 6.

Table 6. Natural Cover Index.

Silver Tip Creek	0.90
Bighorn River	0.90
Crooked Creek	0.88
Bear Creek	0.85
Sage Creek	0.84
Dry Creek	0.79
Elbow Creek	0.78

The Bighorn River and Silver Tip Creek 5th code HUCs have the highest Natural Cover score, with Crooked Creek ranking just below. These three watersheds have the least agricultural development, and indeed all three are mostly in shrub or grass cover. Silver Tip Creek has extensive mining activity, but most of the oil and gas rigs are in the midst of sagebrush steppe, and would be classified as shrub (rather than mining activity) in remote sensing analysis. Elbow Creek has the lowest Natural Cover score at 0.78, reflecting the crop and pasture agricultural activity around the Clark's Fork Yellowstone.

Stream Corridor Integrity Index (I_{SCI})

The Stream Corridor Integrity Index measures the amount of natural land cover within a set buffer on either side of all perennial and intermittent. It was calculated by creating a 60-meter buffer on each side of the stream segments in the 1:100,000 National Hydrography Dataset and assessing land cover and land use from the NLCD. Although higher resolution stream data is available and was used in other calculations (e.g. the Hydrologic Complexity Index), it includes many ephemeral streams and drainages where transport of sediment, runoff and pollution may be minimal. By using lower-resolution data, we hoped to capture perennial and intermittent streams while avoiding ephemeral drainages.

This index offers a way to determine whether areas adjacent to streams are contributing more than

natural amounts of sediment, runoff and pollution. Croplands and fallow fields will produce higher sedimentation rates than naturally vegetated areas (Wilkin and Hebel 1982), and activities that create impermeable cover (particularly roads and commercial, industrial or residential development) will lead to elevated runoff levels, as well as overland transport of chemical pollutants.

Like the Natural Cover Index, the Stream Corridor Integrity Index as developed by Tiner et al. (2000) is generally a simple ratio of naturally vegetated stream corridor to total stream corridor area, with no allowance made for either grazing impacts or types of non-vegetation cover. Accordingly, we weighted the various land uses as we did in the Natural Cover Index, adjusting our assumptions and the assigned weights slightly to reflect the difference in both use and impacts of land use activities on riparian versus upland systems. We assumed, for example, grazing pressure would be better characterized as "moderate" than as "light" in riparian grasslands, as cattle are prone to congregate near sites offering shade and water, but riparian grasslands would be more lush and therefore somewhat more resistant to grazing than more water-stressed uplands. Following Hauer et al. (2001), we therefore gave grasslands in the stream corridor (which we assume are all grazed) a weight of 0.6. Again following the weights assigned by Hauer et al. (2001) for riparian corridors, we changed the weight assigned to hay or pasture from a 0.6 to a 0.5 to reflect the higher risk of erosion, sedimentation and nutrient enrichment from agricultural activities near a stream. However, we did not change the weights of crop and grain production, which were already low (0.2). The weights we used for individual activities in the calculation of the Stream Corridor Index were:

Use	Weight
Other	0.5
Open Water	1.0
Low intensity residential	0.0
Commercial, industrial, transportation	0.0
Bare rock, sand or clay	1.0
Deciduous forest	1.0
Evergreen forest	1.0
Mixed forest	1.0

Shrubland	1.0
Grassland or herbaceous	0.6
Pasture or hay	0.5
Cultivated crops/fallow land	0.2
Developed, open space	0.4
Herbaceous wetlands	1.0
Woody wetlands	1.0

We then calculated this index as:

$$I_{SCI} = A_{LCWt} / A_{TC},$$

where A_{LCWt} = the sum of the weighted scores for land cover in acres and A_{TC} = total stream corridor area, in acres.

We report 60 meters as the buffer width on each side of the streams (120 meters total) because many of the tributary corridors are in relatively confined valleys, but we found little difference between scores calculated with 60, 120, and 180 meter buffers⁴. As can be seen from Table 7, the Bighorn and Silver Tip watersheds have the highest Stream Corridor Integrity, as they did with the Natural Cover Index. Similarly, Elbow Creek and Dry Creek have the lowest scores. Scores on this index are all slightly lower than on the Natural Cover Index, reflecting the concentration of human land uses in valleys and around water sources, but in general most of the stream corridors are not subject to much human use. Many of the perennial streams and rivers retain riparian forests (although these are heavily infested with Russian olive), and those that do not are often in the midst of sagebrush steppe. Grazed grasslands and pastures make up less than 40% of the riparian buffer in all cases. The Silver Tip watershed scored high in Stream Corridor Integrity in part because it has such a low percentage of grassland.

Table 7. Stream Corridor Integrity Index.

Bighorn River	0.88
Silver Tip Creek	0.87
Crooked Creek	0.85
Bear Creek	0.82
Sage Creek	0.81
Elbow Creek	0.77
Dry Creek	0.76

Habitat Disturbance Indices

Riparian Loss Index (I_{RL})

Land use activities within the stream and river corridor are one measure of the departure from natural conditions; another is direct loss of riparian vegetation. This is especially true along the major streams and rivers in the region of the assessment area, where cottonwoods and mixed forests should be dominant land cover features. To approximate riparian loss, we used the 2001 National Land Cover Dataset to create a vegetation layer that includes forested and woody wetland. We buffered all streams from the 1:100,000 National Hydrography Dataset by 60 meters on each side, and calculated the acres of riparian vegetation.

To be on the conservative side, and recognizing the inaccuracies inherent in land cover data at this resolution, we calculated that under natural conditions, the riparian corridor would include at least 30% forest and woody wetland vegetation. Any departure from that was held to be a loss. The index was calculated as:

$$I_{RL} = 1 - (A_{RV}) / (0.50 * A_{TR}),$$

where A_{RV} and A_{RVPR} = the acreage of riparian vegetation within the buffered corridor, and A_{TR} = the total riparian corridor area, in acres.

Table 8 shows the Riparian Loss scores for each watershed; high scores indicate a greater level of disturbance, while low scores equal a lower level. There was a large spread between scores. They ranged from a high of 0.86 for the Silver Tip watershed to a low of 0.09 for the Crooked Creek watershed. The remaining Riparian Loss scores were clustered in the middle range, indicating while some riparian forest remains, it is fragmented by other land uses. We note too that although the Silver Tip Creek watershed is in the Bighorn Basin, which is especially arid, remnant cottonwoods along Silver Tip Creek and Cottonwood Creek indicate there was a riparian forest at one time. It has presumably been lost due to stream incision and diversion of stream flows, both a likely result of human impacts. Therefore, we are comfortable

⁴ We used 60m rather than 50 m because the NLCD is based on 30m grids.

in saying there has been significant loss of woody riparian vegetation since pre-settlement times in this watershed.

Table 8. Riparian Loss Index.

Silver Tip Creek	0.86
Bear Creek	0.68
Dry Creek	0.66
Elbow Creek	0.60
Sage Creek	0.52
Bighorn River	0.51
Crooked Creek	0.09

Road Disturbance Index (I_{RD})

Both improved and unimproved roads compact or cover soil and vegetation, increasing surface runoff. Road rights of way are often fertile ground for exotic species to colonize, and unimproved roads contribute to wind and water-borne erosion and sedimentation. Streams and riparian areas in close proximity to roads are more likely to be affected than those at a greater distance. Because this area is exceptionally dusty during summer months, we chose a 50 meter buffer on each side of the road.

The Road Disturbance Index is calculated as:

$$I_{RD} = ((L_{SR}/L_S) + (RC/L_S)) / 2$$

where LSR = the length of perennial and intermittent streams within 50 meters of a road, in miles, L_S = the total length of perennial and intermittent streams in miles, and RC = the number of road crossings.

We found, in general, roads and road crossings are a disturbance in the assessment area (Table 9). This was born out by our field surveys, where we noted most roads follow valleys, and are often within eyesight of the stream. Road density is highest in the Sage Creek watershed and lowest in the Bighorn River-Layout Creek watershed, which also has the fewest road crossings per stream mile. Sage, Silver Tip and Bear Creek all have the highest number of road crossings per stream mile (0.63, 0.64, and 0.63 respectively).

Table 9. Road Disturbance Index.

Bear Creek	0.51
Sage Creek	0.46
Silver Tip Creek	0.44
Elbow Creek	0.38
Crooked Creek	0.37
Dry Creek	0.35
Bighorn River	0.32

Of course, this index does not take the type or nature of crossings into account; for example, it does not distinguish between paved roads over bridges, improved roads with culverts, and dirt roads that cross stream beds directly. Nor can it pick up the condition of culverts (Figure 17). Culvert design and maintenance can have substantial impacts on aquatic health, especially in areas where roads are minimally maintained. (Furniss et al. 1991). However, it gives a degree of insight into potential management issues in the assessment area.



Figure 17. Poorly maintained culvert near Gyp Spring.

Composite Watershed Condition Index (CWCI)

The Composite Watershed Condition Index is calculated by subtracting the combined disturbance indices from the combined habitat extent indices:

$$CWCI = (I_{NC} + I_{SCI}) - (I_{RL} + I_{RD})$$

The highest possible score would be 2.00, assum-

ing scores of 1.00 (best) on each of the habitat extent indices and 0.00 (best) on each of the disturbance indices. This score would represent the sort of pristine conditions associated with remote, ungrazed wilderness areas with no history of mining, agriculture or other human land use. For inhabited areas, scores will obviously be much lower, and can be a negative number when habitat indices are low and disturbance indices are high. In theory, a watershed in a highly urbanized area with multiple disturbances, alterations, and diversions could score as low as -2.00. Inhabited rural watersheds should score between -1.25 and 1.25, depending on the level of grazing, agriculture and development.

The Composite Watershed Condition scores are shown in Table 10 and in Figure 18. All the watersheds received positive scores, ranging from highs of 1.26 for Crooked Creek to 0.47 for Silver Tip Creek and Bear Creek. In general, this indi-

cates moderate impacts on watershed health and integrity. The highest-scoring Crooked Creek watershed has a high percentage of BLM- and Forest Service-managed land, and its upper reaches are relatively remote. If it were not for the extensive crop agriculture in the lower valley, its score would have been higher. By contrast, the lowest scoring watersheds have multiple impacts. The Silver Tip watershed has extensive mining and agricultural impacts, while much of the Bear Creek watershed has lost riparian forests along tributary streams due to overgrazing, and its lower reaches have a heavy concentration of agriculture.

Composite Watershed Threat Index

The Composite Watershed Condition Index is a measure of how much natural conditions have changed across the subbasin, and in individual watersheds, since Euro-American settlement. The

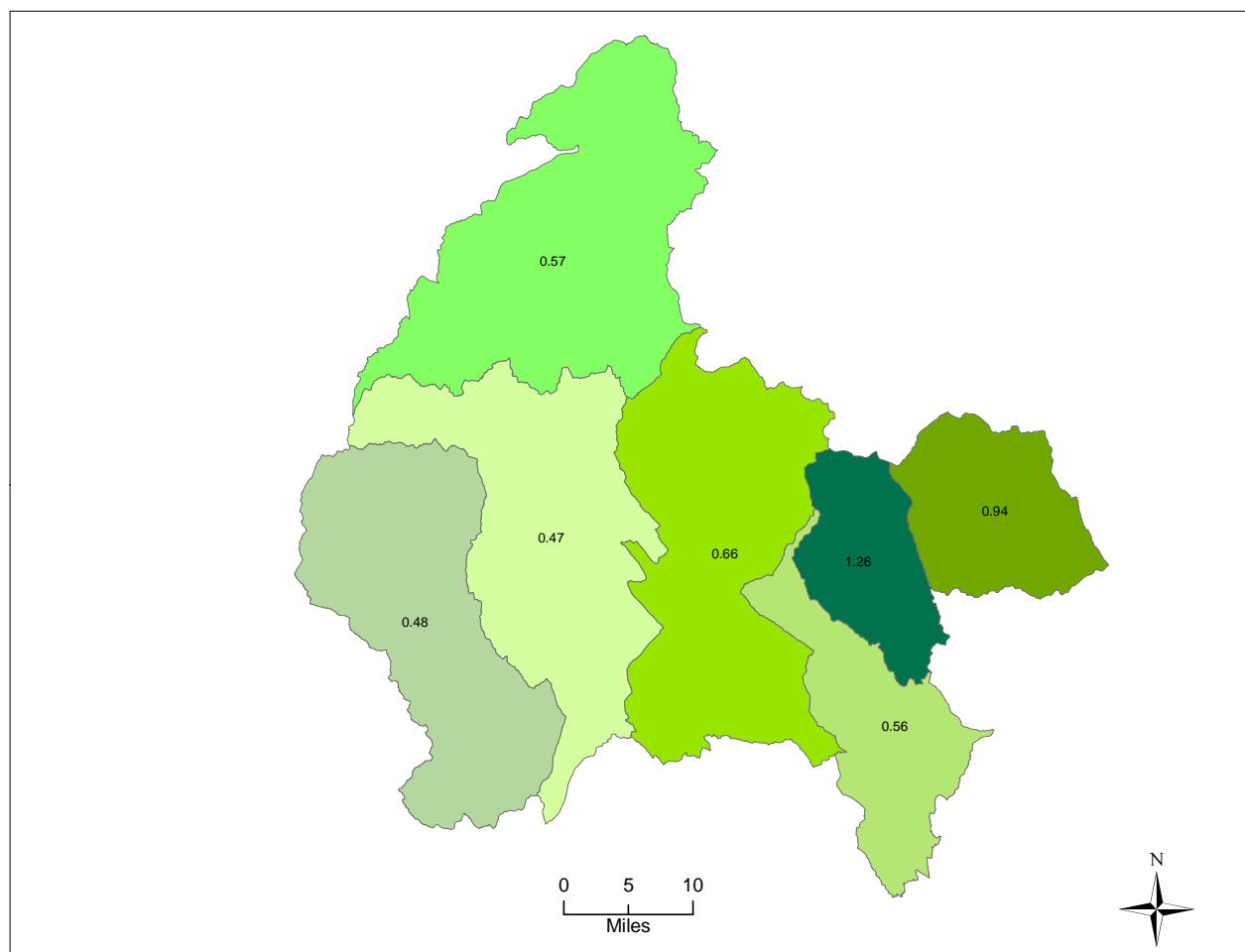


Figure 18. Composite Watershed Condition Index across 5th-code HUCs.

Table 10. Composite Watershed Condition Index.

Crooked Creek	1.26
Bighorn River	0.94
Sage Creek	0.66
Elbow Creek	0.57
Dry Creek	0.56
Silver Tip Creek	0.47
Bear Creek	0.47

Composite Watershed Threat Index, on the other hand, is an attempt to predict which watersheds are most likely to experience continued change and loss of integrity in the future. This is an area where the rate of change slowed following the early mining days. However, new pressures, notably oil and gas extraction and residential development are exerting, and will continue to exert, significant pressures on the area.

In this section, we examine three threats to watershed integrity: energy development, residential development, and grazing. These are in the category of cumulative impact threats, i.e. conditions that are ongoing and that tend to have worsening impacts over time. These threats are by no means an exhaustive list of future possibilities - recreational development and high-impact recreational activities may pose a threat as second home development grows - but they offer some insight into the susceptibility of the individual watersheds to future change.

Oil and Gas Threat Index

Oil and gas development poses a threat on several fronts: clearing of vegetation and soil disturbance associated with building and maintaining roads, facilities and pipelines; direct inputs of oil into streams and rivers when detention ponds fail; regular traffic on dusty roads; and an increase in impacts from bridges, culverts and stream crossings (Figure 19). All these factors can have negative impacts on wildlife and water quality.

Oil and gas extraction has a long history in the area, as mentioned earlier, and existing facilities may pose a greater threat to watershed health and



Figure 19. Pipelines crossing Silver Tip Creek.

integrity than new development. In January 2008, only three new leases were offered in the assessment area; two of these were in the Bear Creek and Silver Tip Creek watersheds, where most existing development is concentrated. However, existing leases are concentrated around these watersheds because of the high volume of oil and gas that has been found there. We decided the best metric for evaluating oil and gas threats was existing leases, and the threat was best measured by looking at acres leased as a percentage of each watershed. We decided too this should be an ordinal scale, since there was no guidance for assigning scores (e.g. 4% or more is an extreme threat, 2% or less is a minor threat, etc). Therefore, we calculated scores for this metric as follows:

$$I_{OG} = (A_{OGL}) / (A_{TW}),$$

where A_{OGL} is the area covered by oil and gas leases (as of 12/2007) and A_{TW} is the total area of the watershed, in acres.

The scores were converted to an ordinal scale by setting the highest percentage as 1 and measuring all other scores as a percentage of that score. Using this calculation, the Silver Tip watershed has the highest threat score, 1, while the others range from 0.74 (Bear Creek) to 0 (Crooked Creek and Bighorn River-Layout Creek) (Table 11).

Table 11. Oil and Gas Threat Index.

Silver Tip Creek	1.00
Bear Creek	0.74
Dry Creek	0.30
Sage Creek	0.28
Elbow Creek	0.04
BigHorn River	0.00
Crooked Creek	0.00

Sales set for Bear and Elbow in January 08

Residential Development Threat Index

While we do not expect the assessment area will see the kind of growth that has occurred just to the west in Red Lodge, the proximity of much of the study area to Red Lodge and Billings, coupled with relatively low land prices, makes it likely growth will occur (Figure 20). Like oil and gas development, residential development leads to surface disturbance and landscape fragmentation, creation of impervious surfaces, pressures on surface and groundwater, and increases in sedimentation from dusty roads and motorized recreation.



Figure 20. Land for sale, Bear Creek watershed.

We made several assumptions in calculating this index: first, that most development would occur in areas of fairly gentle relief; second, that it would be concentrated within a mile of existing roads; third, that it would occur on lands currently used for grazing, rather than crop agriculture; and fourth, that it would occur soonest in areas where there was existing infrastructure, i.e. near other residen-

tial development. Therefore, the index assesses the relative availability of lands meeting those criteria. It was calculated for each watershed by assigning scores of 1 to 7 in each of three categories: 1) total acres of lands meeting the first three assumptions given above (7=largest acreage); 2) average parcel size of private lands (7=smallest average size); and 3) number of private parcels 20 acres or less (7=largest number). The resulting scores were relativized by dividing all scores by the highest score (Table 12).

Table 12. Residential Development Threat Index.

Bear Creek	1.00
Elbow Creek	0.71
Silver Tip Creek	0.65
Bighorn River	0.53
Dry Creek	0.53
Sage Creek	0.53
Crooked Creek	0.41

The Residential Development index could not be calculated for all watershed areas, because Wyoming does not maintain a centralized, digital database of cadastral records. However, based on Montana's records, the Bear Creek watershed faces the greatest residential development threat, followed by the Elbow Creek watershed. This was borne out by our field observations; we saw evidence of recent subdivision (electrical boxes, driveways) southwest of Belfry, extending into the foothills below the Meeteetse Spires, and noted several houses under construction.

Riparian Grazing Threat Index (I_{GT})

Cattle grazing can cause soil compaction, nutrient enrichment, vegetation trampling and removal, habitat disturbance, and, depending on the season and intensity of use, reproductive failure for both plants and animals. In riparian areas, grazing can cause stream bank destabilization, loss of riparian shade, and increased sediment and nutrient loads (George et al. 2002). To assess this threat, we used the same 50 meter buffers we used in the calculation of the riparian loss index, but here we measured the percentage of those buffers which were either under public land ownership (assumed to be

available for grazing) or were private but listed in cadastral records as having grazing as a primary use. These buffers are narrow to capture the most intense riparian grazing effects (bank collapse, loss of vegetation filtering function, etc) and to allow a cross-comparison to the Riparian Loss Index.

The Riparian Grazing Threat Index was then calculated as:

$$I_{GT} = A_{RG}/A_{RT},$$

where A_{RG} is the area of public and private grazing land in the stream buffers and A_{RT} is the total buffer area, in acres. These scores were then converted to an ordinal scale by dividing all scores by the highest score.

Table 13 has a breakdown of Riparian Grazing Threat scores for each of the 5th code watersheds. Two caveats are in order here. First, the scores represent a potential threat, and not necessarily an existing threat. For instance, riparian areas in the Silver Tip and Bear Creek watersheds, which have the highest scores on this metric, are not necessarily in worse condition than any other 5th code watershed; management practices may limit riparian grazing, and the land itself may be unsuitable for grazing, or may not be grazed at all. Rural land with no other agricultural use is typically designated as grazing land for tax purposes, regardless of whether it is actually grazed. Moreover, management practices and stocking rates will determine actual condition. Second, low scores only indicate potential grazing threats, not impacts that may have already occurred. However, both the Silver Tip and Bear Creek watersheds also had high scores on the riparian loss index, suggesting grazing is in fact exerting a negative impact on riparian vegetation. We would note, too, our field observations confirmed cattle were congregating in the remaining cottonwood stands in the upper parts of the Bear Creek watershed, and loafing under the few remnant trees in the Silver Tip watershed. Therefore, we consider this index to be an especially important one to managers.

Table 13. *Riparian Grazing Threat Index.*

Silver Tip Creek	1.00
Bear Creek	0.95
Elbow Creek	0.91
Crooked Creek	0.78
Sage Creek	0.43
Dry Creek	0.38
Bighorn River	0.23

Composite Threat Index (CTI)

The Composite Threat Index is a simple sum of the three sub-indices, with the maximum possible score being 3.0, indicating a high degree of threats:

$$CTI = I_{GT} + I_{NWT} + IPAT$$

Table 14 shows the Composite Threat for individual watersheds. The scores for the Bear Creek and Silver Tip Creek watersheds indicate a high threat level for these watersheds. We should note, too, we did not calculate a weed disturbance index in this assessment, as we have in previous years, because we felt the available data was too out of date. However, during our field surveys, we saw considerable weediness in both these watersheds, although we also noted weed control efforts underway in the Bear Creek watershed. In short, these two watersheds are at risk from multiple sources, and therefore offer several land management opportunities. In the other five watersheds, the scores are not especially high, and in the case of Bighorn Creek are quite low. We do caution, however, that most of the Dry Creek watershed is in Wyoming, and because cadastral data for that state is unavailable, scores are only calculated based on the Montana portion of the watershed. Based on our field observations, if data were available to accurately assess the extent of the riparian grazing and residential development threats, the composite score for Dry Creek (and to a lesser extent, Sage and Crooked Creeks) would be much higher.

We were not able to quantify threats related to fire, although we observed widespread past wildland fire activity in the Crooked Creek watersheds, and fires burned near the assessment area through the

Table 14. Composite Threat Index.

Bear Creek Creek	2.69
Silver Tip Creek	2.65
Elbow Creek	1.66
Sage Creek	1.24
Dry Creek	1.20
Crooked Creek	1.20
Bighorn River	0.76

summer of 2007 (Figure 21). During our field surveys, however, we did not observe notable insect damage or disease in the forests in upper Bear Creek, and only minor impacts in Sage Creek. However, this was not the purpose of our surveys, and so they were by no means exhaustive.



Figure 21. Burned forest in Crooked Creek watershed.

Interpreting the Broad-scale Assessment Composite Indices

Although it may be tempting to continue to reduce the composite assessment indices to a single number, we have kept them separate because each represents a distinct and important piece of the watershed assessment. The Composite Natural Complexity Index provides a basis for assessing the raw material, i.e. the range of natural variability within the individual watersheds, which can be used as a surrogate for natural or background conditions. From a management standpoint, watersheds with high natural complexity are those where unique natural features are likely to occur, and may

therefore warrant more detailed assessment. The Composite Watershed Condition Index represents overall change in natural conditions, allowing us to compare individual watersheds and identify factors like stream corridor land use patterns or road density that impact overall condition. The Composite Threat Index is a measure of what can still be lost. This index should be interpreted on its own, or at most in relation to the Composite Watershed Condition Index. For example, the Silver Tip Creek watershed has relatively low Composite Watershed Condition, and high Composite Threats. This could indicate habitat values are compromised, though on-site investigation would be needed to determine the extent of vulnerability. By contrast, the Crooked Creek watershed has high Natural Complexity, Watershed Condition, and among the lowest Composite Threats. This indicates management activities are working, and continued improvements will not be unduly compromised by the assessed threats.

Fine-scale Assessments

During the summer of 2007, MTNHP ecologists surveyed streams, springs and wetlands at 73 sites, and carried out aquatic surveys for fish and macro-invertebrates at 13 sites (See Figure 10). All sites were in the Bear Creek, Silver Tip Creek, Sage Creek, Crooked Creek and Bighorn River-Layout Creek watersheds, where BLM ownership is highest. Individual rankings and comments are found in Appendix A. The results are summarized below.

Wetland and Riparian Assessments

Of the 73 stream, wetland and spring sites assessed, we found:

- 37 in Proper Functioning Condition with a stable trend;
- 14 in Proper Functioning Condition with a downward trend;
- 6 Functioning at Risk with a stable trend;
- 2 were Functioning at Risk with an upward trend;
- 12 were Functioning at Risk with a downward trend;
- 1 Functioning at Risk with an unknown trend;
- 4 Not Functioning.

Of 41 sampling sites believed to be on BLM-managed lands, we found:

- 17 in Proper Functioning Condition with a stable trend (Figure 22);
- 9 in Proper Functioning Condition with a downward trend;
- 3 Functioning at Risk with a stable trend;
- 2 were Functioning at Risk with an upward trend;
- 8 were Functioning at Risk with a downward trend (Figure 23);
- 2 Not Functioning (Figure 24).

Given the percentage of BLM ownership in the assessment area, these figures suggest BLM-managed riparian and wetland sites are in no better or worse condition than those managed by others. There is, however, a strong geographic trend. All but one of the sites in the Bighorn River-Layout Creek watershed were ranked PFC; the remaining site was non-functioning, having been completely degraded by cattle. Most of the sites in the Crooked Creek watershed had an upward trend, based on PFC or FAR ratings. All of the sites along Sage Creek



Figure 22. A proper functioning condition riparian site on Bridger Creek.



Figure 23. A stable but functioning at risk ephemeral draw in Hunter Creek.



Figure 24. A non-functioning site on private land in the Bear Creek watershed.

were found to be functioning at risk with either a stable or downward trend, primarily because of water diversions, heavy weed infestations, and eroding banks. In the Cottonwood Creek and Hunter Draw areas, most sites were in proper functioning condition, but several were ranked as having a downward trend because of weeds, grazing pres-

sure, and lack of woody regeneration. One wetland site in the Hunter Draw subwatershed was ranked PFC with a downward trend because it is becoming overgrown with cattails, although it is otherwise in very good condition.

Sites along Silver Tip Creek were generally in proper functioning condition, although we noted there had been severe flooding, apparently due to a detention pond failing upstream (Jay Parks, BLM, personal communication, July 18, 2007). The creek is very incised in places, but is building a new floodplain. It appeared salt cedar along the creek had been chemically treated, although we saw some signs of regeneration. Cattle were present in one area, but were generally absent from the channel. Nonetheless, water quality seems questionable at best. During all our visits (3), the water was turbid and both the water and vegetation reeked of oil. Aquatic sampling in Silver Tip Creek indicated impaired condition.

Sites near Bridger Creek, also in the Silver Tip watershed, were generally good, although we saw significant signs of potential impairment in the spring that feeds the creek: salt cedar, Russian olive, thistle and hound's tongue were all present at the spring itself, and burrowing by rabbits has undermined the stability of the terraces surrounding the spring.

The quality of sites in the Bear Creek watershed varied widely, mostly due to cattle impacts. Sites in the more upland areas near the Meeteetse Trail were generally good, while sites farther downstream were more likely to be functioning at risk or functioning with a downward trend. Although efforts have been made to fence cattle out of springs, the fences are often in poor repair.

Thirty-six of the sites we visited had been surveyed in 2005 (Appendix B). Of those, seven had degraded, 19 had improved, and 10 had stayed the same. In many cases the improvement was minimal - from Functioning at Risk with an upward trend to Proper Functioning Condition with a downward trend - but it did suggest to us management efforts are having a positive effect. Sites in the Hunter Creek draw were in much better condi-

tion than reported in 2005. One site that went from Proper Functioning Condition with a stable trend to Functioning at Risk with a downward trend (on Grove Creek) did so because a culvert blew out, changing the stream flow and attracting cattle to a vegetated area.

In general, weeds and grazing were the two biggest impacts seen at the assessment sites, with weeds being the more intractable problem from a management standpoint.

Fish and Macroinvertebrate Assessments

As a second component of our fine-scale assessment work, we sampled and assessed aquatic community integrity based on macroinvertebrate, fish and habitat sampling (Figure 25). Our goal was to identify and interpret key community indicators found at the sites using standardized protocols and biotic thresholds, and to compare these against reference condition standards at the watershed-level and local-reach scale. The goals of the fine-scale



Figure 25. Sampling in Bear Creek, May 2007.

aquatic assessment were 1) to sample and assess aquatic community integrity based on macroinvertebrate, fish and habitat sampling at sites selected by BLM management (Table 15), and 2) to identify and interpret key community indicators found at the sites, and compare these against reference condition standards at the watershed-level and local-reach scale.

Habitat Evaluations. We conducted onsite habitat assessments using the rapid assessment protocol developed for the EPA by Barbour et al. (1999) with modifications and additions by the National Aquatic Assessment of the BLM (Hawkins et al. 2003). Using the BLM assessment protocols, the reach was divided into ten equally spaced transects. Parameters recorded at each were: wetted width; bankfull width; three channel depth measurements; large woody debris; and riparian shading. Basic water chemistry parameters (temperature, pH, conductivity, dissolved O₂) were recorded prior to sampling using a Horiba H-10 water monitor. The goal of these evaluations is to characterize local reach geomorphology, riparian and in-stream habi-

tat, and other characteristics that influence aquatic community integrity. Higher ranks indicate higher quality local-scale habitat. Habitat assessments were performed during the same visit as the biological sampling.

Fish Communities. Fish sampling in the foothill streams was conducted with a Smith Root Backpack Electroshocker Model #15-B following protocols outlined in EPAs Rapid Bioassessment Protocol (RPB; Barbour et al. 1999). This required the positioning of upstream and downstream block nets at the ends of the reach (150 meters or 40 times wetted width), but most of the time shallow sections and/or riffle areas were sufficient to prevent fish from escaping while the run and pool areas were being shocked. Fish sampling in the valley streams was conducted with 20 foot straight seines following protocols outlined in Bramblett et al. (2005). Fish captured using either method were transferred to holding buckets, identified to species, counted, examined for external anomalies (e.g. deformities, eroded fins, lesions, and tumors), and then released. Young-of-the-year under 20

Table 15. BLM Clark's Fork Yellowstone 2007 aquatic sites. Sites with an asterisk (*) were also sampled or a nearby reach was visited by NHP or DEQ in 2004, 2005.

BLM CFY Aquatic Sites	HUC	Latitude	Longitude	Date Sampled	Water Flow Condition
*Bear Creek	10070006	45.14233	-109.04185	30-Jul-07	water flowing
Bear Creek #2	10070006	45.16391	-109.11028	12-Jun-07	water flowing bankfull
*Clark's Fork Yellowstone River #1	10070006	45.2639	-108.91147	30-Jul-07	water flowing
*Clark's Fork Yellowstone River #2	10070006	45.106	-109.0247	30-Jul-07	water flowing
Cottonwood Creek	10070006	45.08825	-108.8135	12-Jun-07	drying, recently wetted
Dillworth Creek #1	10070006	45.04714	-109.1014	13-Jun-07	dry
Dillworth Creek #2	10070006	45.05402	-109.1333	13-Jun-07	dry
Gold Creek Spring	10070006	45.07695	-109.18938	13-Jun-07	trickle spring flow
Gold Creek	10070006	45.07704	-109.18826	13-Jun-07	trickle flow
*Grove Creek	10070006	45.07616	-109.08412	12-Jun-07	trickle flow
Gyp Spring	10070008	45.00563	-108.4296	12-Jun-07	water flowing
North Fork Grove Creek	10070006	45.09573	-109.17846	13-Jun-07	water flowing, recently filled
Sage Creek	10080014	45.00929	-108.62682	13-Jun-07	water flowing, recently filled
South Fork Bridger Creek	10070006	45.21127	-108.84092	14-Jun-07	water flowing
South Fork Bridger Creek Spring	10070006	45.20484	-108.822	14-Jun-07	water flowing
*Silver Tip Creek #1	10070006	44.99972	-108.9029	12-Jun-07	water flowing bankfull
*Silver Tip Creek #2	10070006	45.08825	-108.8135	12-Jun-07	water flowing bankfull
Wolf Creek	10070006	45.10889	-109.03973	12-Jun-07	dry
Wolf Creek tributary	10070006	45.11668	108.8135	12-Jun-07	dry

millimeters in length were noted on the field sheet (not included in the totals), and released. Voucher specimens were only taken in cases of uncertain field identifications.

Analysis of the valley stream fish communities used Integrated Biotic Indices (IBI) for prairie streams (Bramblett et al. 2005) and derived Observed/Expected (O/E) Fish Models (Stagliano 2005) to detect impairment in the biological integrity of the sites. The IBI involved calculation of a series of metrics evaluating different attributes of the community. The metrics allowed calculation of an overall score between 0 and 100. Biological community integrity was calculated at the foothills stream sites using Fish (O/E), since IBIs have not been sufficiently developed for these mountain foothill streams and would rank impaired with the prairie IBI. Bramblett et al. (2005) did not propose threshold criteria for good, fair, and poor biological integrity for these scores. Therefore, we applied commonly used criteria. Scores of 75 to 100 indicate good to excellent biological integrity, 50-74 fair to good biological integrity, 25 to 49 indicated poor to fair biological integrity and scores <25% indicate poor biological integrity or severely impaired.

Macroinvertebrate Communities. Macroinvertebrates were collected from 10 evenly spaced transects across the reach with a 500-micron D-frame net. The method utilized was the EMAP Reach-Wide Multi-habitat protocol outlined in Lazorchak (1998). All 10 samples taken within the designated transects were composited into a bucket, and the organisms were washed onto a 500-micron sieve, transferred to a one-liter Nalgene bottle, labeled

and preserved in 95% ethanol and brought to the MTNHP lab in Helena for processing.

These samples were processed (sorting, identification, and data analysis) by David Stagliano at the Helena NHP lab following Montana Department of Environmental Quality's protocols (MTDEQ 2005). Macroinvertebrates were identified to the lowest taxonomic level, identifications were imported into EDAS (Jessup 2006), and biological metrics were calculated from the data using the newest multimetric macroinvertebrate (MMI) protocols (Jessup et al. 2005, Feldman 2006). Metric results were then scored using the Montana DEQ bioassessment criteria and each sample categorized as non-impaired or impaired according to threshold values (Table 16).

The impairment threshold set by MT DEQ is **37** for the Eastern Plains Stream Index, and **48** for the Low Mountain/Valley Index; therefore any scores above this threshold are considered unimpaired. The macroinvertebrate MMI score is based upon a series of metrics that measure attributes of benthic macroinvertebrate communities regarding condition changes to a stream system (in the form of anthropogenic caused changes).

Sampling site selection. All sites chosen for this BLM watershed assessment lie within the Billings Field Office Management Area in Carbon Co., MT. Habitat assessments, water quality measurements, macroinvertebrate and/or fish surveys were to be performed at 10 predetermined lotic (stream) sites (per conversation with J. Platz) and an additional two spring-influenced sites within the BLM lands of the Watershed Assessment Region. Five of the

Table 16. Impairment determinations from the MMI and O/E (RIVPACS) models (taken from Jessup et al. 2005, Feldman 2006).

Ecoregion	RIVPACS	MMI	Impairment Determination
Mountain	≥ 0.8 or ≤ 1.2	≥ 63	Not impaired
	< 0.8 or > 1.2	< 63	Impaired
Low Valley	≥ 0.8 or ≤ 1.2	≥ 48	Not impaired
	< 0.8 or > 1.2	< 48	Impaired
Eastern Plains	≥ 0.8 or ≤ 1.2	≥ 37	Not impaired
	< 0.8 or > 1.2	< 37	Impaired

predetermined stream sites (Dillworth (2), Gold and Wolf Creek (2) as well as five other randomly visited sites were dry, so additional sites on BLM lands were added (Table 15). All streams with water present had macroinvertebrate samples taken. Four of the eight sites sampled for fish had fish present. Biological community integrity was calculated at all sites using Fish Observed/Expected Models (O/E), since Fish Integrated Biotic Indices (IBI's) have not been sufficiently developed for these mountain foothill streams and would rank impaired with the Prairie Fish IBI. Macroinvertebrate multi-metrics (MT DEQ MMIs) were calculated for all sites. Site summary descriptions based on the overall community integrity and site observations are included in Appendix C.

Results Summary. The Clark's Fork of the Yellowstone River study area is a typical example of a sage-dominated Montana Foothills/Wyoming Basin landscape transitioning to Northwestern Great Plains grasslands. We identified fish and macroinvertebrate communities with moderate ecological integrity within three Aquatic Ecological System Types (AES) during this study: Intermountain Transitional River (B003), Small Foothills Streams (C001), and Northwestern Great Plains/Wyoming Basin Perennial Spring Perennial (S005). We found significant environmental factors exist in this region (e.g. oil and gas fields, water diversions, improper grazing practices), and these factors appear to impair the biological health of some aquatic ecological systems, notably Silver Tip Creek, South Fork Bridger Creek, and Grove Creek).

Overall, three of the 13 visited lotic sites had good habitat quality ranked by at least one of the habitat assessment methods (Appendix B - Table B1). Of the others, five were ranked slightly impaired and five moderately to severely impaired. Sage Creek, Bear Creek and North Fork Grove Creek had the highest habitat quality scores, using both EPA RBP and BLM habitat assessment methods. Riparian assessment scores were most often reduced by stream sediments, bare ground, and bank trampling from livestock intrusions. These intrusions were measured using the Livestock Use Index (LUI), which was very high for several streams including South Fork Bridger, Cottonwood, Wolf and Grove

Creeks. High sediment loading was measured at both Silver Tip Creek sites, and in Grove and South Fork Bridger Creeks. The water conductivity values taken at both Silver Tip Creek sites and Clark's Fork Yellowstone Site #1 were above the threshold (3,000 μ s) for the water quality impairment level (MTDEQ 2006) (Appendix B).

Three native fish species, the longnose dace (*Rhinichthys cataractae*), and longnose and white suckers (*Catostomus catostomus* and *C. commersoni*), were identified with only 64 individuals total from the 13 lotic BLM sites sampled in 2007 (Appendix B - Table B2). In the Clark's Fork of the Yellowstone (which was not sampled) four to six species have been reported in the Bridger Creek section (MTFWP 2006). Fish presence and individual numbers were lower than expected, possibly due to recent high water events causing redistribution of existing populations, or in the case of Sage Creek, by having only recently been recolonized. Fish species richness averaged less than one per site (fish present sites-2.) The most diverse sites were Bear Creek and South Fork Bridger Creek, both with three native species present. Longnose dace were collected at all five of the fish presence sites and white suckers at four of the five. Using the Observed/Expected Models, three of the five fish sites were ranked non-impaired (good biological integrity), one was slightly impaired (moderate integrity) and the one spring site (South Fork Bridger Spring) is questionable, because this stream type is usually fishless. We consider the stream reaches of Grove Creek and both sites of Silver Tip Creek moderate to severely impaired (poor biotic integrity), because these stream types should contain fish, but none were collected. This impairment (shown in the MMI results, is manifested by an absence of the expected fish species.

We identified 112 macroinvertebrate taxa from the BLM assessment sites (Appendix B - Table B3). Average richness of macroinvertebrate 22 taxa per site, with a maximum richness of 32 taxa at two sites. Using the Montana DEQ multimetric index (MMI), nine of the 13 sites were ranked non-impaired (good to excellent biological integrity), three were slightly impaired and one was severely impaired (Appendix B - Table B3). Silver

Tip Creek showed severe impairment close to the Wyoming border but improved approximately four miles downstream at the next sampling site. This downstream reach shows improvement in the macroinvertebrate community since DEQ last sampled there in 2004, with MMI scores increasing from 31.2 to 52.4 (Appendix B - Table B3). At most stream sites sampled in 2004 and 2007, MMI scores were in agreement. One site that has significantly degraded is Grove Creek. When we visited this site in 2005, MMI scores ranked the macroinvertebrate community as having high biological integrity; 2007 sampling ranks it as impaired. We observed significant degradation by cattle and much lower flows than the same time period in 2005.

Combining results from the habitat, fish and macroinvertebrate surveys enabled us to rank sites from highest biological integrity to lowest, by Aquatic Ecological System type:

Overall Aquatic Ecological System Site Condition (in order of highest integrity to lowest by Aquatic Ecological System):

Intermountain Transitional River

- 1) Clark's Fork of the Yellowstone River Bridger Bend (Site #2)
- 2) Clark's Fork of the Yellowstone River (Site #1)

Small Transitional Foothills River

- 1) Bear Creek
- 2) Sage Creek
- 3) South Fork Bridger Creek
- 4) Grove Creek

Small Foothills Stream

- 1) North Fork Grove Creek
- 2) Gold Creek
- 3) Dillworth Creek

Northwestern Great Plains Intermittent Prairie Stream

- 1) Wolf Creek
- 2) Cottonwood Creek
- 3) Silver Tip Creek Site #2
- 4) Silver Tip Creek Site #1

Northwestern Great Plains/Wyoming Basin Perennial Spring

- 1) Gyp Spring
- 2) Bridger Creek Spring
- 3) Gold Creek Spring

Relationship Between Broad-scale and Fine-scale Assessments

It is useful to distinguish between cumulative impacts and cumulative effects (Johnson 2005). Broad-scale assessments look at impacts, i.e. the activities and events that change natural conditions, while fine-scale assessments examine the results of those impacts. In the assessment area, water diversions and impoundments are impacts, while dewatered streams, non-functioning wetlands or loss of species are effects. Impacts may occur at a significant distance from their effects, as is often the case with upstream-downstream relationships observed in aquatic systems, or they may occur in close proximity. For example, impacts from land use activities in upstream watersheds may have effects downstream, with the biological integrity of a given aquatic survey being characterized as "impaired." On the other hand, the higher population density, greater percentage of agricultural use, and increased movement of machinery associated with crop agriculture may lead to a relatively localized spread of noxious weeds and exotic species.

The value of watershed-level assessments lies in identifying areas where impacts are currently occurring or may occur, rather than merely documenting effects that have already occurred. By combining both site-level and watershed-level assessments, it is possible to select areas where management can make a substantial difference in future wetland and aquatic health. Thus, even when there are similar findings between the two levels of assessment, they need to be examined less for correlation than for the different perspectives they provide.

In this case, our fine-scale assessments revealed important details about subwatersheds not apparent from broad-scale assessments; for example, it allowed us to identify Bridger Creek and Hunter's Draw as relatively high-quality areas within the

Silver Tip watershed. Similarly, our aquatic assessments reflected landscape-level impacts better than the riparian assessments, especially in the case of Silver Tip Creek, where riparian structure is generally good but biological integrity is poor. Furthermore, our fine-scale assessments enabled us to identify invasive species and grazing as the major impacts on wetlands and streams. In short, fine-scale assessments offer specific guidance to management. Some of those management opportunities are discussed in the final section.

MANAGEMENT OPPORTUNITIES

The BLM owns and administers a substantial proportion of land within the assessment area, and can play an important role in conserving or restoring natural functioning. Based on our broad-scale and fine-scale assessments, and observations in the field, we have identified several specific management opportunities.

Invasive Species

Many of the exotic species we observed are not considered noxious (e.g. cheatgrass, smooth and Japanese brome, yellow sweetclover). However, we did see several stands of Canada thistle and whitetop along Sage Creek. In fact, the extensive wetlands to the northeast of the main Highway 310 crossing are severely infested with whitetop. Unfortunately, this is private land, and unless the landowner's cooperation can be secured, public land management will have to focus on downstream control rather than eradication. We also saw knapweed near reservoirs and along roadsides, and Russian olive was common (Figure 26). As



Figure 26. Russian olive in Bear Creek.

noted earlier, the Shoshone River has also been invaded by salt cedar. Russian olive and salt cedar can dominate riparian woody vegetation with potentially dire consequences for wildlife habitat if education followed by control are not successful. While salt cedar infestation is driven in part by upstream activities, vigilant monitoring by BLM staff, permittees and leaseholders may still prevent its spread. In general, there is a good opportunity for preventing the spread of weeds into weed-free parts of the watershed, which will minimize weed-driven loss of range forage and riparian plant communities.

Grazing Management

Although several springs and riparian areas have been negatively impacted by grazing (Figure 27), our field surveys indicated rangelands across the assessment area are in generally good condition, and reflect conscious grazing management. However, riparian vegetation represents an especially attractive resource for cattle and sheep, and the shade riparian trees provide is attractive during all hot summer days. We believe in non-drought years, flows in the tributaries would be sufficient to reestablish cottonwood and aspen, and stream restoration efforts could be fruitful in the upper portions of the Bear Creek watershed if grazing could be managed or excluded. We also noted efforts have been made to this effect in the woody wetlands in that watershed.



Figure 27. Heavily impacted site, Bear Creek watershed.

We also noted habitat could be improved by excluding cattle from springs and spring overflow areas and by providing additional watering opportunities to minimize impacts. Again, we recognize stock ponds exist to water stock, but note larger reservoirs could be managed for habitat as well as cattle watering. These management practices, coupled with frequent utilization monitoring, and the use of physical barriers where necessary, will help provide impaired resources with the opportunity to recover.

Recreation Management

Off-road vehicle use appears to be widespread in portions of the assessment area, especially closer to the population centers of Wyoming (Figures 28 and 29).



Figure 28. ORV tracks near Crooked Creek.



Figure 29. ORV trail into lower Gyp Spring.

The 4-wheeler intrusions on the lower end of Gyp Spring were a particular concern; although they had not driven through the spring itself, there was nothing to prevent that in the future. We also noted a hidden hunting camp just downstream from Piney Creek spring. While recreation does not seem to pose a great threat to streams and wetlands in the assessment area at this time, future residential development in both Wyoming and Montana may necessitate a management response.

Fisheries Management

As we noted earlier, Crooked Creek has what is believed to be the most eastern population of Yellowstone cutthroat trout. During the summer of 2007, crews were working on a fish barrier to prevent non-native brown trout from swimming upstream to where the native cutthroat population is concentrated (Figure 30). We also saw a beaver dam downstream of the barrier, which may also block upstream migration (Figure 31). With ongoing monitoring, these efforts appear to be sufficient to accomplish the fisheries management goals in this watershed.



Figure 30. Fish barrier construction, Crooked Creek.



Figure 31. Beaver dam downstream of fish barrier.



Figure 33. Terrace near collapse at Cherry Springs.

Watershed-specific Management Efforts

During our field surveys, we observed multiple impacts at Cherry Spring in the lower Silver Tip watershed, one of the most reliable sources of water on the eastern side of the assessment area (Figure 32 and 33). One of the most severe impacts was rabbit overpopulation. The soils around Cherry

Spring are very fine silty loams, and extensive burrowing has significantly undermined the banks and the entire terrace around the spring, leading to serious headcutting and bank collapse. Cattle grazing in the area is moderate, but given the unstable ground, it will exacerbate streambank collapse. Protecting this habitat will require immediate action to eradicate the rabbit population.



Figure 32. Lateral cutting near Cherry Springs.

Although Silver Tip Creek itself has been severely impacted by energy extraction, several of the sub-watersheds have intact wetland resources. We were surprised to find a relatively large wetland in the Hunter Creek area, and noted it had been fenced, presumably to exclude cattle (Figure 34). We noted this wetland is being choked with cattail and suggest it be revisited to determine if limited grazing would be beneficial.



Figure 34. Wetland in Hunter Creek drainage.

Habitat protection will require grazing impacts in the Bear Creek watershed be addressed, and other riparian areas with non-functioning or functioning at risk/downward determinations be targeted for management. As noted earlier, we think some riparian vegetation could be restored in this watershed through grazing management.

We also suggest managers explore opportunities for collaboration with the landowner on Sage Creek whose wetlands are severely infested with whitetop and other weeds (Figure 35). This wetland complex is extensive, and there is substantial BLM-managed land downstream. Weeds are problematic throughout this watershed, but this particular occurrence represents a major source for whitetop, an especially aggressive invader.



Figure 35. Thistle in Sage Creek.

Finally, we reiterate population growth in response to oil and gas development in the coming years may place unforeseen pressures on public land resources. The distinct topography of this area makes it attractive for off-roading, and the relatively light pressures experienced now may grow exponentially in coming years. Intermittent streambeds often attract off-road use, and a proactive stance will be critical to limiting unrestrained use of these areas.

LITERATURE CITED

- Barbour, M., J. Gerritsen, B. D. Snyder, and J. B. Stribling. 1999. Rapid Bioassessment Protocols for Use in Streams and Wadable Rivers: Periphyton, Benthic Macroinvertebrates and Fish, Second Edition. EPA 841-B-99-002. United States Environmental Protection Agency; Office of Water: Washington, DC.
- Bramblett, R. G., T. R. Johnson, A. V. Zale, A. V., and D. Heggen. 2005. Development and Evaluation of a Fish Assemblage Index of Biotic Integrity for Northwestern Great Plains. *Transactions of the American Fisheries Society* 134:624–640, 2005.
- Chapman, S. S., S. A. Bryce, J. M. Omernik, D. G. Despain, J. ZumBerge, and M. Conrad. 2004. Ecoregions of Wyoming (color poster with map, descriptive text, summary tables, and photographs): Reston, Virginia, U.S. Geological Survey (map scale 1:1,400,000).
- Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, M. Pyne, M. Reid, K. Schulz, K. Snow, and J. Teague. 2003. Ecological Systems of the United States: A Working Classification of U.S. Terrestrial Systems. NatureServe, Arlington, Virginia. 83 pp.
- Cowardin L. M., V. Carter, F. C. Golet and E. T. LaRoe. 1979. Classification of wetlands and deepwater habitats of the United States. US-FWS, Office of Biol. Ser. (FWS/OBS-79/31), December 1979. 103 pp.
- Crowe, E. C. and G. Kudray. 2003. Wetland Assessment of the Whitewater Watershed. Report to the Bureau of Land Management. Montana Natural Heritage Program, Helena, MT. 106 pp.
- Dorn, R. D. 1984. Vascular Plants of Montana. Mountain West Publishing, Cheyenne, WY. 276 pp.
- Feldman, D. 2006. Interpretation of New Macroinvertebrate Models by WQPB. Draft Report. Montana Department of Environmental Quality, Planning Prevention and Assistance Division, Water Quality Planning Bureau, Water Quality Standards Section. 1520 E. 6th Avenue, Helena, MT 59620. 14 pp.
- Furniss, M. J., T. D. Roeloffs, and C. S. Yee. 1991. Road construction and maintenance. Pages 297-323 *In* W. R. Meehan, Editor, Influences of Forest and Rangeland Management on Salmonid Fishes and Their Habitats. Special Publication 19. American Fisheries Society, Bethesda, Maryland.
- George, M. R., R. E. Larsen, N. K. McDougald, K. W. Tate, J. D. Gerlach, Jr., and K. O. Fulgham. 2002. Influence of grazing on channel morphology of intermittent streams. *J. Range Management*. 55:551-557.
- Great Plains Flora Association. 1977. Atlas of the Flora of the Great Plains. Ames, IA. Iowa State University Press. 600 pp.
- Great Plains Flora Association. 1986. Flora of the Great Plains. Lawrence, KS. University Press of Kansas. 1400 pp.
- Grossman, D. H., D. Faber-Langendoen, A. S. Weakley, M. Anderson, P. Bourgeron, R. Crawford, K. Goodin, S. Landaal, K. Metzler, K. Patterson, M. Pyne, M. Reid, and L. Sneddon. 1998. International Classification of Ecological Communities: Terrestrial Vegetation of the United States. Volume I. The national vegetation classification system: development, status, and applications. The Nature Conservancy, Arlington, Virginia. USA. 126 pp.
- Hamilton, J. M. 1957. From Wilderness to Statehood: A History of Montana 1805-1900. Bindfords and Mort, Portland, OR. 667 pp.

- Hauer, F. R., B. J. Cook, M. C. Gilbert, E. C. Clairain, Jr., and R. D. Smith. 2001. The Hydrogeomorphic Approach to Functional Assessment: A Regional Guidebook for Assessing the Functions of Riverine Floodplain Wetlands in the Northern Rocky Mountains. Special Publ. WES, USCOE, Vicksburg, MS. 255 pp.
- Hauer, F. R., B. J. Cook, M. C. Gilbert, E. C. Clairain, Jr., and R. D. Smith. May 2002. A Regional Guidebook for Applying the Hydrogeomorphic Approach to Assessing Wetland Functions of Intermontane Prairie Pothole Wetlands in the Northern Rocky Mountains. Special Publication ERDC/EL TR-02-7. WES, USCOE, Vicksburg, MS. 118 pp. plus appendices.
- Hawkins, C., J. Ostermiller, M. Vinson and R. J. Stevenson. 2003. Stream Invertebrate and Environmental Sampling Associated with Biological Water Quality Assessments. Western Center for Monitoring and Assessment of Freshwater Ecosystems, BLM National Aquatic Monitoring Center, Utah State University, Logan, Utah. 11 pp.
- Jessup, B., J. Stribling, and C. Hawkins. 2005. Biological Indicators of Stream Condition in Montana Using Macroinvertebrates. Tetra Tech, Inc. November 2005 (draft).
- Jessup, B. 2006. Ecological Data Application System (EDAS) Version MT 3.3.2k A User's Guide. Tetra Tech, Inc.
- Johnson, J. B. 2005. Hydrogeomorphic wetland profiling: An approach to landscape and cumulative impacts analysis. EPA/620/R-05/001. U.S. Environmental Protection Agency, Washington, DC.
- Kartesz, J. T. 1999. A synonymized checklist and atlas with biological attributes for the vascular flora of the United States, Canada, and Greenland. In J. T. Kartesz and C. A. Meacham, editors, Synthesis of the North American flora, version 1.0. North Carolina Botanical Garden, Chapel Hill, North Carolina.
- Lazorchak, J. M., D. J. Klemm and D. V. Peck (eds.). 1998. Environmental Monitoring and Assessment Program-Surface Waters: Field Operations and Methods for Measuring the Ecological Condition of Wadeable Streams. EPA/620/R-94/004F. U.S. Environmental Protection Agency, Washington, D.C.
- Montana Department of Environmental Quality (MTDEQ). 2005. Sample Collection, Sorting, and Taxonomic Identification of Benthic Macroinvertebrates. Water Quality Planning Bureau. Standard Operation Procedure (WQPBWQM-009).
- Montana Department of Environmental Quality (MTDEQ). 2007. Montana Department of Environmental Quality TMDL Planning Area Completion Schedule. Available at: <http://www.deq.state.mt.us/wqinfo/TMDL/2007TMDL%20Schedule.pdf>.
- Montana Fish, Wildlife & Parks (FWP). 2006. Montana Fisheries Information System. Database query available at: <http://maps2.nris.mt.gov/scripts/esrimap.dall?name=MFISH&Cmd=INST>
- Mincemoyer, S. 2006. Surveys of Significant Plant Resources in Southeast and South-central Montana on the Billings and Miles City Field Offices of the Bureau of Land Management. Report to the USDI Bureau of Land Management, Billings and Miles City Field Offices. Montana Natural Heritage Program, Helena, MT. 22 pp. plus appendices.
- Moyle, P. B. and M. P. Marchetti. 1999. Applications of indices of biotic integrity to California streams and watersheds. Pages 367-382 In T. P. Simon, editor, Assessing the sustainability and biological integrity of water resources using fish communities. CRC Press, Boca Raton, FL. 671 pp.
- Omernik, J. M. 1987. Ecoregions of the conterminous United States (map supplement): Annals of the Association of American Geographers, v. 77, no. 1, p. 118-125, scale 1:7,500,000.

- Power, M. E., G. Parker, W. E. Dietrich, and A. Sun. 1995. How does floodplain width affect floodplain river ecology? A preliminary exploration using simulations. *Geomorphology* 13: 301-317.
- Pritchard, D., F. Berg, W. Hagenbuck, R. Krapf, R. Leinard, S. Leonard, M. Manning, C. Noble and J. Staats. 1999. Riparian Area Management: a user guide to assessing proper functioning condition and the supporting science for lentic areas. TR 1737-16. Bureau of Land Management, BLM/RS/ST-99/001+1737, National Applied Resource Sciences Center, CO.
- Rosenzweig, M. L. 1995. Species diversity in space and time. Cambridge University Press, New York, NY.
- Stagliano, David, M. 2005. Aquatic Community Classification and Ecosystem Diversity in Montana's Missouri River Watershed. Report to the Bureau of Land Management. Montana Natural Heritage Program, Helena, Montana. 65 pp. plus appendices.
- Tiner, R., M. Starr, H. Bergquist, and J. Swords. 2000. Watershed-based wetland characterization for Maryland's Nanticoke River and Coastal Bays watersheds: A preliminary assessment report. U.S. Fish & Wildlife Service, National Wetlands Inventory (NWI) Program, Northeast Region, Hadley, MA. Prepared for the Maryland Department of Natural Resources, Coastal Zone Management Program (pursuant to National Oceanic and Atmospheric Administration award). NWI technical report.
- Vance, L. K. 2005. Watershed assessment of the Cottonwood and Whitewater watersheds. Report to the Bureau of Land Management. Montana Natural Heritage Program, Helena, MT. 57 pp. plus appendices.
- Vance, L., D. Stagliano, and G. M. Kudray. 2006. Watershed Assessment of the Middle Powder Subbasin, Montana. A report to the Bureau of Land Management, Montana State Office. Montana Natural Heritage Program, Helena, Montana. 61 pp. plus appendices.
- Vance, Linda K. and David M. Stagliano. 2007. Watershed Assessment of Portions of the Lower Musselshell and Fork Peck Reservoir Subbasins. Report to the Bureau of Land Management, Lewistown Field Office. Montana Natural Heritage Program, Helena, MT. 41 pp. plus appendices.
- Wilkin D. C. and S. J. Hebel. 1982. Erosion, redeposition and delivery of sediment to mid-western streams. *Water Resour. Res.*, 18:1278-1282.
- Woods, A. J., J. M. Omernik, J. A. Nesser, J. Sheldon, J. A. Comstock, and S. H. Azevedo. 2002. Ecoregions of Montana, 2nd edition (color poster with map, descriptive text, summary tables, and photographs). Map scale 1:1,500,000.

**APPENDIX A. PROPER FUNCTIONING CONDITION RANKINGS FOR
WETLAND AND RIPARIAN SURVEY SITES**

Metric	LO-07-101	LO-07-102	LO-07-104	LO-07-105	LO-07-107	LO-07-108	LO-07-111	LO-07-114
1. Floodplain inundated in relative frequent events	N	N	Y	Y	Y	Y	Y	Y
2. Active/stable beaver dams	N	N	N	N	N	N	N	N
3. Sinuosity, width/depth, gradient in balance	N	Y	Y	N	N	Y	Y	N
4. Riparian zone widening or has reached potential	Y	Y	Y	Y	N	N	Y	N
5. Upland watershed not contributing to degradation	Y	Y	Y	Y	Y	Y	Y	Y
6. Diverse age-class distribution	Y	N	Y	N	N	N	Y	Y
7. Diverse composition of vegetation	N	N	Y	N	N	N	Y	Y
8. Species indicate maintenance of riparian soil moisture	N	N	Y	Y	Y	Y	Y	Y
9. Streambank veg composed of plants with binding rootmass	N	Y	Y	N	N	N	Y	N
10. Riparian plants exhibit high vigor	N	N	Y	N	N	N	Y	N
11. Adequate veg to protect banks and dissipate flows	N	Y	Y	Y	Y	N	Y	N
12. Plant communities an adequate source of LWD	Y	N	Y	Y	N	N	Y	N
13. Floodplain and channel adequate to dissipate energy	N	Y	Y	Y	N	N	Y	N
14. Point bars revegetating	N	Y	Y	N	N	N	Y	Y
15. Lateral movement associated with sinuosity	N	N	Y	N	Y	Y	Y	N
16. System vertically stable	N	N	Y	Y	Y	Y	Y	N
17. Stream in balance with water and sediment	N	Y	Y	N	N	N	Y	Y
Summary determination	NF	FAR/D	PFC/S	FAR/D	FAR/D	FAR/D	PFC/S	FAR/D

Metric	LO-07-123	LO-07-124	LO-07-125	LO-07-126	LO-07-127	LO-07-128	LO-07-129	LO-07-130
1. Floodplain inundated in relative frequent events	N	N	N	Y	Y	Y	N	Y
2. Active/stable beaver dams	N/A	N/A	N/A	Y	Y	Y	N	N
3. Sinuosity, width/depth, gradient in balance	N	Y	N	Y	Y	Y	Y	N
4. Riparian zone widening or has reached potential	N	Y	N	Y	Y	Y	N	N
5. Upland watershed not contributing to degradation	N	Y	Y	Y	Y	Y	N	N
6. Diverse age-class distribution	N	Y	Y	Y	Y	Y	N	N
7. Diverse composition of vegetation	N	Y	Y	Y	Y	Y	N	Y
8. Species indicate maintenance of riparian soil moisture	N	Y	Y	Y	Y	Y	N	N
9. Streambank veg composed of plants with binding rootmass	N	Y	Y	Y	Y	Y	N	Y
10. Riparian plants exhibit high vigor	N	Y	N	Y	Y	Y	N	N
11. Adequate veg to protect banks and dissipate flows	N	Y	N	Y	Y	Y	Y	Y
12. Plant communities an adequate source of LWD	Y	Y	Y	Y	Y	Y	Y	Y
13. Floodplain and channel adequate to dissipate energy	Y	Y	Y	Y	Y	Y	Y	Y
14. Point bars revegetating	N	Y	Y	Y	Y	Y	N	N
15. Lateral movement associated with sinuosity	N	Y	N	Y	Y	Y	Y	Y
16. System vertically stable	Y	Y	N	Y	Y	Y	Y	Y
17. Stream in balance with water and sediment	N	Y	Y	Y	Y	Y	Y	Y
Summary determination	NF	PFC/S	FAR/UK	PFC/S	PFC/S	PFC/S	FAR/D	FAR/S

Metric	LO-07-131	LO-07-132	LO-07-133	LO-07-134	LO-07-135	LO-07-137	LO-07-138	LO-07-139
1. Floodplain inundated in relative frequent events	N	N	N	Y	Y	Y	Y	Y
2. Active/stable beaver dams	N	N	N	N/A	N/A	N/A	N/A	N/A
3. Sinuosity, width/depth, gradient in balance	Y	Y	Y	N	Y	Y	Y	Y
4. Riparian zone widening or has reached potential	N	N	N	Y	Y	N	Y	N
5. Upland watershed not contributing to degradation	N	N	N	Y	Y	Y	Y	Y
6. Diverse age-class distribution	N	N	Y	Y	N	N	Y	N
7. Diverse composition of vegetation	N	N	Y	N	N	Y	Y	Y
8. Species indicate maintenance of riparian soil moisture	N	N	Y	Y	N	Y	Y	Y
9. Streambank veg composed of plants with binding rootmass	N	N	Y	Y	N	Y	Y	Y
10. Riparian plants exhibit high vigor	N	N	Y	Y	Y	N	N	N
11. Adequate veg to protect banks and dissipate flows	Y	Y	Y	Y	Y	Y	Y	Y
12. Plant communities an adequate source of LWD	Y	Y	Y	Y	Y	Y	Y	Y
13. Floodplain and channel adequate to dissipate energy	Y	Y	Y	Y	Y	Y	Y	Y
14. Point bars revegetating	N	N	Y	Y	Y	Y	Y	Y
15. Lateral movement associated with sinuosity	Y	Y	Y	Y	N	Y	Y	Y
16. System vertically stable	Y	Y	Y	N	N	N	Y	N
17. Stream in balance with water and sediment	Y	Y	Y	Y	N	Y	Y	Y
Summary determination	FAR/D	FAR/D	PFC/D	PFC/D	FAR/D	PFC/D	PFC/S	

Metric	LO-07-140	LO-07-141	LO-07-142	LO-07-143	LO-07-144	LO-07-145	LO-07-146	LO-07-147
1. Floodplain inundated in relative frequent events	Y	Y	Y	Y	Y	Y	Y	Y
2. Active/stable beaver dams	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N
3. Sinuosity, width/depth, gradient in balance	N	Y	Y	N	N	N	Y	Y
4. Riparian zone widening or has reached potential	N	Y	N	N	N	N	N	Y
5. Upland watershed not contributing to degradation	Y	N	N	N	N	N	N	Y
6. Diverse age-class distribution	Y	N	N	N	N	N	N	Y
7. Diverse composition of vegetation	Y	Y	Y	N	Y	Y	N	Y
8. Species indicate maintenance of riparian soil moisture	Y	Y	Y	Y	Y	Y	Y	Y
9. Streambank veg composed of plants with binding rootmass	N	Y	Y	Y	Y	Y	Y	Y
10. Riparian plants exhibit high vigor	N	Y	N	N	N	N	Y	Y
11. Adequate veg to protect banks and dissipate flows	N	Y	Y	Y	Y	Y	Y	Y
12. Plant communities an adequate source of LWD	Y	N	N	N	Y	Y	Y	Y
13. Floodplain and channel adequate to dissipate energy	N	Y	Y	Y	Y	Y	Y	Y
14. Point bars revegetating	Y	Y	Y	Y	Y	Y	Y	Y
15. Lateral movement associated with sinuosity	N	Y	Y	N	N	N	N	Y
16. System vertically stable	N	Y	Y	Y	Y	Y	Y	Y
17. Stream in balance with water and sediment	Y	Y	Y	Y	Y	Y	Y	Y
Summary determination	FAR/D	PFC/S	PFC/D	FAR/U	PFC/D	PFC/D	PFC/D	PFC/S

Metric	LO-07-148	LO-07-149	LO-07-150	LO-07-151	LO-07-152	LO-07-153	LO-07-154	LO-07-155
1. Floodplain inundated in relative frequent events	Y	Y	Y	Y	Y	Y	Y	Y
2. Active/stable beaver dams	N	N	N	N	N	N	N	N
3. Sinuosity, width/depth, gradient in balance	Y	Y	N	Y	Y	Y	Y	Y
4. Riparian zone widening or has reached potential	Y	Y	Y	N	Y	Y	Y	Y
5. Upland watershed not contributing to degradation	Y	Y	N	N	Y	Y	Y	Y
6. Diverse age-class distribution	Y	Y	Y	N	Y	Y	Y	Y
7. Diverse composition of vegetation	Y	Y	Y	Y	Y	Y	Y	Y
8. Species indicate maintenance of riparian soil moisture	Y	Y	Y	Y	Y	Y	Y	Y
9. Streambank veg composed of plants with binding rootmass	Y	N	Y	N	Y	Y	Y	Y
10. Riparian plants exhibit high vigor	Y	Y	Y	N	Y	Y	Y	Y
11. Adequate veg to protect banks and dissipate flows	Y	N	N	N	Y	Y	Y	Y
12. Plant communities an adequate source of LWD	Y	Y	Y	N	Y	Y	Y	Y
13. Floodplain and channel adequate to dissipate energy	Y	Y	N	N	Y	Y	Y	Y
14. Point bars revegetating	Y	Y	N	N	Y	Y	Y	Y
15. Lateral movement associated with sinuosity	Y	N	N	N	Y	Y	Y	Y
16. System vertically stable	Y	Y	N	N	Y	Y	Y	Y
17. Stream in balance with water and sediment	Y	Y	N	N	Y	Y	Y	Y
Summary determination	PFC/S	PFC/D	FAR/D	NF	PFC/S	PFC/S	PFC/S	PFC/S

Metric	LO-07-156
1. Floodplain inundated in relative frequent events	Y
2. Active/stable beaver dams	N
3. Sinuosity, width/depth, gradient in balance	N
4. Riparian zone widening or has reached potential	N
5. Upland watershed not contributing to degradation	Y
6. Diverse age-class distribution	N
7. Diverse composition of vegetation	N
8. Species indicate maintenance of riparian soil moisture	Y
9. Streambank veg composed of plants with binding rootmass	N
10. Riparian plants exhibit high vigor	N
11. Adequate veg to protect banks and dissipate flows	N
12. Plant communities an adequate source of LWD	Y
13. Floodplain and channel adequate to dissipate energy	Y
14. Point bars revegetating	N
15. Lateral movement associated with sinuosity	Y
16. System vertically stable	N
17. Stream in balance with water and sediment	Y
Summary determination	FAR/D

Metric	LE-07-136	LE-07-103	LE-07-106	LE-07-109	LE-07-110	LE-07-112	LE-07-113	LE-07-157
1) Riparian-wetland area is saturated at or near the surface	Y	Y	Y	Y	Y	Y	Y	Y
2) Fluctuation of water levels is not excessive	Y	Y	N	Y	Y	Y	Y	Y
3) Riparian-wetland area is enlarging or has achieved potential	Y	Y	Y	N	N	Y	N	Y
4. Upland watershed is not contributing to degradation	Y	Y	N	Y	Y	Y	Y	Y
5) Water quality is sufficient to support riparian-wetland plants	Y	Y	Y	Y	Y	Y	Y	Y
6) Natural flow patterns are not altered by disturbance	Y	Y	N	N	N	Y	Y	Y
7) Structure accommodates safe passage of flows	Y	N/A	Y	Y	N/A	Y	N/A	N/A
8) There is diverse age-class distribution	N	Y	N	N	N	Y	N	Y
9) There is diverse composition	N	Y	N	N	N	Y	N	Y
10) Species indicate riparian-wetland soil moisture	Y	Y	Y	Y	N	Y	Y	Y
11) Root masses withstand impacts	Y	Y	Y	Y	N	Y	Y	Y
12) Riparian-wetland plants exhibit high vigor	Y	Y	Y	N	N	Y	N	Y
13) Adequate vegetative cover	Y	Y	Y	N	N	Y	N	Y
14) Frost or abnormal hydrologic heaving is not present	Y	Y	Y	Y	Y	Y	Y	Y
15) Favorable microsite condition	Y	Y	Y	Y	Y	Y	Y	Y
16) Accumulation of chemicals not apparent	Y	Y	Y	Y	Y	Y	Y	Y
17) Saturation of soils	Y	Y	Y	Y	Y	Y	Y	Y
18). Substrate capable of restricting percolation	Y	Y	Y	Y	Y	Y	Y	Y
19) Riparian-wetland is in balance with water and sediment	Y	Y	N	Y	Y	Y	Y	Y
20) Shoreline characteristics can dissipate energy	N/A	N/A	Y	N/A	N/A	N/A	N/A	N/A
Summary determination	PFC/D	PFC/S	PFC/D	FAR/S	FAR/D	PFC/S	FAR/U	PFC/S

Metric	LE-07-158
1) Riparian-wetland area is saturated at or near the surface	Y
2) Fluctuation of water levels is not excessive	Y
3) Riparian-wetland area is enlarging or has achieved potential	Y
4. Upland watershed is not contributing to degradation	Y
5) Water quality is sufficient to support riparian-wetland plants	Y
6) Natural flow patterns are not altered by disturbance	Y
7) Structure accommodates safe passage of flows	Y
8) There is diverse age-class distribution	Y
9) There is diverse composition	Y
10) Species indicate riparian-wetland soil moisture	Y
11) Root masses withstand impacts	Y
12) Riparian-wetland plants exhibit high vigor	Y
13) Adequate vegetative cover	Y
14) Frost or abnormal hydrologic heaving is not present	Y
15) Favorable microsite condition	Y
16) Accumulation of chemicals not apparent	Y
17) Saturation of soils	Y
18). Substrate capable of restricting percolation	Y
19) Riparian-wetland is in balance with water and sediment	Y
20) Shoreline characteristics can dissipate energy	N/A

**APPENDIX B. TABULAR RESULTS OF FISH AND
MACROINVERTEBRATE SURVEYS**

Table B1. Site habitat and WQ parameters for aquatic sites included in the BLM surveys LUI=Livestock Use Index, Cond=Conductivity, % fines averaged across all transects. Bolded readings represent values exceeding DEQ water quality impairment standards.

Site	Date Sampled	Avg wetted width (m)	Avg channel depth (cm)	Reach Length (m)	EPA Habitat Quality Index (HQI)	BLM Site Eval	LUI	% fines in reach	pH	Cond	DO (mg/L)	Water Temp (C)
*Bear Creek	30-Jul-07	2.5	20.2	150	182	22	7	5.0	7.7	456	10.1	13.6
Bear Creek #2	12-Jun-07	2.3	18.5	150	172	20	6	12.0	7.2	288	9.7	16.5
*Clarks Fork Yellowstone River #1	30-Jul-07	42.5	65.0	200	168	20	0	6.0	6.9	4120	5.2	23.1
*Clarks Fork Yellowstone River #2	30-Jul-07	58.5	75.0	300	170	21	3	6.0	7.6	2240	4.3	22.1
Cottonwood Creek	12-Jun-07	dry	dry	na	na	na	28	na	na	na	na	Na
Dillworth Creek #1	13-Jun-07	dry	dry	na	na	na	5	na	na	na	na	Na
Dillworth Creek #2	13-Jun-07	dry	dry	na	na	na	12	na	na	na	na	Na
Gold Creek Spring	13-Jun-07	1.8	5.0	25	160	20	0	20.0	7.9	110	5	15.1
Gold Creek	13-Jun-07	dry	dry	na	na	na	20	na	na	na	na	Na
*Grove Creek	12-Jun-07	2.6	17.2	150	144	16	22	20.0	8.0	123	10.5	15.7
Gyp Spring	12-Jun-07	2.8	10.5	100	172	22	0	16.0	7.9	327	10	9.7
North Fork Grove Creek	13-Jun-07	2.1	12.0	150	178	21	0	<1	7.1	180	12	8.6
Sage Creek	13-Jun-07	4.2	25.0	150	188	23	5	4.0	7.2	110	5	22.5
South Fork Bridger Creek	14-Jun-07	1.8	11.3	150	150	15	35	25.0	7.5	2020	8	16.3
South Fork Bridger Creek Spring	14-Jun-07	1.3	14.9	50	168	18	10	5.0	7.6	550	10	14.8
Silvertip Creek #1	12-Jun-07	1.1	55.0	150	116	14	4	91.0	7.9	4390	2.5	25.4
Silvertip Creek #2	30-Jul-07	2.0	35.8	150	127	15	18	78.0	8.1	5590	3.2	25.3
Wolf Creek	12-Jun-07	dry	dry	na	Na	na	33	na	na	na	na	na
Wolf Creek trib	12-Jun-07	dry	dry	na	Na	na	28	na	na	na	na	na

Table B2. Fish site species info. Seine (+) = additional seine hauls conducted or (++) full seining protocol used. *Shallow enough to visually observe absence of fish.

BLM CFY Aquatic Sites	Shock Time (Sec)	Seine	Longnose Dace	White Sucker	Longnose Sucker	Total Individuals
Bear Creek	1580	+	4	2	1	7
Bear Creek #2	1390	+	8	2	2	12
Gold Creek & Gyp Spring*	0		0	0	0	0
Grove Creek	650		0	0	0	0
Grove Creek (NHP 2005)	600		0	0	0	0
North Fork Grove Creek	355		0	0	0	0
Sage Creek	1220		12	1	0	13
South Fork Bridger Creek	1098	+	22	4	1	27
South Fork Bridger Creek Spring	387		6	0	0	5
Silvertip Creek #1	687	++	0	0	0	0
Silvertip Creek #2	723	++	0	0	0	0

Table B3. Fish and macroinvertebrate metrics. LVAL/PL=Low mountain-valley or plains designation, MT MMI= Multimetric Macroinvertebrate Index and Observed/Expected (O/E) scores for the lotic study sites. Bold-underlined scores are good-excellent index scores, shaded grey represent fair-good local-reach conditions. Fish (+) = present, (-) = sampled no fish, NS = not sampled for fish.

BLM CFY Aquatic Sites	LVAL/ PL	# Macro Species	MT MMI	FISH	# FISH Species	Fish O/E
Bear Creek	LVAL	30	<u>63.6</u>	+	3	<u>75%</u>
Bear Creek #2	LVAL	29	<u>63.9</u>	+	3	<u>75%</u>
Bear Creek (DEQ 2004)	LVAL	25	<u>56.3</u>	+	NS	NS
Clarks Fork Yellowstone River #1	LVAL	32	<u>59.8</u>	+	NS	NS
Clarks Fork Yellowstone River #1 (DEQ Sept. 2004)	LVAL	30	<u>52.7</u>	+	NS	NS
Clarks Fork Yellowstone River #2	LVAL	31	<u>60.7</u>	+	NS	NS
Clarks Fork Yellowstone River 2 (DEQ Sept. 2004)	LVAL	29	<u>59.7</u>	+	NS	NS
Cottonwood Creek	PL	No inverts	0	dry	dry	0
Cottonwood Creek (DEQ 2004, private reach)	PL	24	<u>66.2</u>	NS	NS	NS
Dillworth Creek #1	LVAL	No inverts	0	dry	dry	0
Dillworth Creek #2	LVAL	No inverts	0	dry	dry	0
Gold Creek Spring	LVAL	7	43.5	-	0	0
Gold Creek	LVAL	No inverts	0	dry	0	0
Grove Creek	LVAL	20	42.4	-	0	0
Grove Creek (NHP 2005)	LVAL	22	<u>72.6</u>	NS	NS	NS
Gyp Spring	LVAL	32	<u>66.2</u>	-	0	0
North Fork Grove Creek	LVAL	8	<u>72.6</u>	-	0	0
Sage Creek	LVAL	0	0	+	2	50%
South Fork Bridger Creek	LVAL	10	37.3	+	3	<u>75%</u>
South Fork Bridger Creek Spring	LVAL	13	<u>56.9</u>	+	1	?
Silvertip Creek #1	PL	4	18.2	-	0	0
Silvertip Creek1(DEQ 2004)	PL	8	27.5	NS	NS	NS
Silvertip Creek #2	PL	22	<u>52.4</u>	-	0	0
Silvertip Creek2(DEQ 2004)	PL	19	31.4	NS	NS	NS
Wolf Creek	PL	No inverts	0	dry	dry	0
Wolf Creek trib	PL	No inverts	0	dry	dry	0

APPENDIX C. AQUATIC AND MACROINVERTEBRATE SITE DESCRIPTIONS

Intermountain Mainstem River (AES B005)

Management/Threats to this ecological system include:

Grazing and livestock use around the riparian areas occurs and can have strong local effects resulting in sedimentation and stream widening at cattle crossings. Introductions of game or forage fish in stock ponds anywhere in the watershed can make their way downstream to these perennial prairie rivers and become permanent residents. Periodic Dewatering is a significant problem within the Clark's Fork of the Yellowstone tributaries and mainstem.

Clark's Fork Yellowstone (Mainstem Site #1 above Bridger Creek)

Location: Accessed from bridge crossing and proceeded upstream ~50m to the first riffle/pool set designated the top of the reach. **Nearest Town:** Bridger

Ecoregion: Wyoming Basin/Northwestern Great Plains (Typical)

Aquatic Ecological System Type: B003-Intermountain Transitional River.

Key Environmental Factors: Hydrology - upstream diversions in the watershed; Riparian Grazing - no immediate impacts, Riparian Modifications - moderate impacts from riprap (left photo, upstream-river right)

Rare or Unique Species: No rare species, but a fairly intact and diverse intermountain macroinvertebrate assemblage. **Rare Features:** None

Introduced/Exotic Aquatic Species: Extensive stand of Russian olive trees upstream of reach. Introduced fish - Rainbow and Brown Trout reported in this reach (FWP MFISH)

Overall Ecological Site Condition: Fair



Reach Summary: The 300m reach consisted of 1 riffle/run/pool complex with run geomorphology dominating the reach (200m) averaging 0.6m in depth. The lowermost pool was ~50m long, averaged 1m deep and contained the most fish holding habitat. This stream reach lacked a diversity of microhabitats, cobbles dominated the substrate (70% of transects) and lacked undercut banks or large woody debris. The substrate of the pool was gravel/pebble dominated with some silt and cobbles. Aquatic geomorphic features, riparian vegetation and overhanging banks provided the most significant stream fish habitat in this reach.

Vegetation coverage along the riparian stream channel was dominated by grasses/shrubs and largely intact. Livestock use index (LUI) was low with 0 cow pies counted on a 75m walk of both left and right banks.

Reach Riparian Ranking: BLM = 84% (20 of 24) EPA RBP = 83.3% (168 of 200)

Reach Riparian Geomorphology: The geomorphology of this stream a riffle-pool configuration with substrate dominated by cobble/gravel and ranging to pebble/silt-dominated pools. Wetted width of the reach was 42.5 m. Surrounding bank materials are finer than the channel bed materials.

Fish were not sampled at this site. Although, longnose dace were captured while sampling for macroinvertebrates, and Rainbow and Brown Trout were reported in this reach (FWP MFISH). Expected fish species for this stream type would also include longnose, mountain and white suckers.

Fish Community Quality: NA

Macroinvertebrate Community Quality: MTMMI = 59.8

Clark's Fork Yellowstone (Bridger Bend FAS Mainstem Site #2)

Location: Accessed from FWP Fishing Access parking lot and proceeded upstream ~100m to demarcate the top of reach and 300m downstream designated the bottom of the reach (Photo Looking Downstream).

Ecoregion: Wyoming Basin/Northwestern Great Plains (Typical)

Aquatic Ecological System Type: B003-Intermountain Transitional River.

Key Environmental Factors: Hydrology - upstream dams or diversions in the watershed; Riparian Grazing - slight impacts right bank, Riparian Modifications - slight impacts from road riprap, river left (Left Photo)

Rare or Unique Species: No rare species., but a fairly intact intermountain macroinvertebrate assemblage.

Rare Features: None

Introduced/Exotic Aquatic Species: Rainbow and Brown Trout, Russian Olive Trees

Overall Ecological Site Condition: Fair-Good



Reach Summary: The 300m reach consisted of 1 long riffle/run/pool complex with riffle geomorphology dominating the reach (200m) averaging 0.25m

in depth (see photos). The lowermost pool was ~50m long, averaged 1m deep and contained the most fish holding habitat. This stream reach lacked a diversity of microhabitats, cobbles dominated the substrate (80% of transects) and lacked undercut banks or large woody debris. The substrate of the pool was pebble dominated with some silt and cobbles. Vegetation coverage along the riparian stream channel was dominated by grasses/shrubs and largely intact. Livestock use index (LUI) was low with 0 cow pies counted on a 75m walk of both left and right banks.

Reach Riparian Ranking: BLM= 75% (18 of 24) EPA RBP= 85% (170 of 200)

Reach Riparian Geomorphology: The geomorphology of this stream a riffle-pool configuration with substrate dominated by cobble/gravel and ranging to pebble/silt-dominated pools. Wetted width of the reach was 58.5m. Surrounding bank materials are finer than the channel bed materials.

Fish were not sampled at this site. Although, longnose dace were captured while sampling for macroinvertebrates, and Rainbow and Brown Trout were reported in this reach (FWP MFISH). Expected fish species for this stream type would also include longnose, mountain and white suckers

Fish Community Quality: NA

Macroinvertebrate Community Quality: MTMMI= 60.7

Bear Creek (Sites 1 & 2--BLM & State Section)

Location: Off highway 308, 2-3 miles west of Belfry

Ecoregion: Wyoming Basin Sage Foothills trending to Northwestern Great Plains

Aquatic Ecological System Type: C001-Small Transitional Foothills River

Key Environmental Factors: Hydrology - upstream diversions in tributaries of the watershed; Riparian Grazing - slight to moderate impacts,

Rare or Unique Species: No rare species, but abundant *Ophiogomphus severus* dragonfly larvae

Rare Features: No rare features documented

Introduced/Exotic Aquatic Species: Extensive stand of Russian olive trees within and upstream of reach.

Overall Ecological Site Condition: Fair trending to Good



Reach Summary:

This stream reach has moderate quality instream aquatic habitat and good fish species diversity (3 fish species). Substrate was dominated by gravel/pebble in the runs and the pools were gravel/silt dominated. Aquatic vegetation and overhanging banks provided the most significant stream habitat and shading in this stream reach. Livestock use index (LUI) was slight to moderate with 7 and 6 cow pies counted on a 75 m walk of each reach. Pugging and hummocking was minimal

Riparian Ranking: BLM= #1-92% (22 of 24) / #2-80% (20 of 24) EPA RBP=#1- 91% (182 of 200) #2- 86% (172 of 200)

Reach Riparian Geomorphology: The geomorphology of this stream reach is a Rosgen F-4 with a gentle-medium slope (1.5 %), moderate sinuosity, a run-dominated configuration with substrate dominated by pebble/gravels and silt embedded pools. Pools are slightly incised and averaged >30 cm in depth, wetted width of the reach was 2.5. Surrounding bank materials are similar to the channel bed materials indicating a balance of sediment accumulation locally and upstream in the reach.

Fish Community: Three fish species were shocked in the 2 reaches of stream (150m--2 riffle/run/pool sequences). Dominant species were the longnose dace, longnose and white suckers. Expected fish for this stream type have almost been met, just missing the mountain sucker and potentially the flathead chub.

Fish Community Quality: O/E= 3/4 or 75% of the expected fish community

Macroinvertebrate Community: This community is dominated by the Medium Coolwater Transitional Assemblage (#1, Stagliano 2005) and members of the Small Foothills Transitional Assemblage (#9, Stagliano 2005). (#105, Stagliano 2005) Over 80% of the indicator species were present in this sample.

Macroinvertebrate Community Quality: Reach #1-MMI = 63.6 #2 – MMI = 63.9

Cottonwood Creek (dry)

Location:

Ecoregion: Pryor/Bighorn Mountain Foothills - Northwestern Great Plains

Montana Foothills and Valleys



Aquatic Ecological System Type: D005-Northwestern Great Plains Intermittent Stream

Key Environmental Factors: Hydrology - upstream dams or diversions in tributaries of the watershed; Riparian Grazing - moderate impacts.

Rare or Unique Species: No rare species

Rare Features:

No rare features documented

Introduced/Exotic Aquatic Species: None collected.

Overall Ecological Site Condition: Fair trending to Good

Reach Riparian Ranking: BLM = NA EPA RBP = NA

Reach Geomorphology: Surrounding bank materials are finer than the channel bed materials

Fish Community: No fish species collected, stream reaches dry. Expected fish for this stream type have not been met.

Fish Community Quality: IBI = 0 O/E = 0 / 2.7 or 0% of the expected fish community

Macroinvertebrate Community: No macroinvertebrate species collected stream reaches dry.

Macroinvertebrate Community Quality: MMI = 0 O/E = 0%.

Sage Creek (BLM Bear Canyon Section)

Location: Shoshone drainage, just upstream of Bear Canyon Creek near town of Warren

Ecoregion: Wyoming Basin Foothills trending to Northwestern Great Plains

Aquatic Ecological System Type: C001-Small Foothills River

Key Environmental Factors: Hydrology - recently refilled channel, upstream dams or diversions in tributaries of the watershed; Riparian Grazing - slight impacts



Rare or Unique Species: No rare species

Rare Features: No colonized aquatic macroinvertebrates yet, really strange - fish moved in within days.

Introduced/Exotic Aquatic Species: None documented

Overall Ecological Site Condition: Fair trending to Good

Fish Community: 2 pioneering fish species (Longnose Dace and White Suckers) were shocked in the 2 riffle/run/pool sequences.

Fish Community Quality: O/E = 2/4 or 50% of the expected fish community

Macroinvertebrate Community: This macroinvertebrate community was absent, it had not recolonized the dry stream bed yet. 0 % of the indicator species were present in this sample.

Macroinvertebrate Community Quality: MT MMI = 0

South Fork Bridger Creek (BLM site)

Ecoregion: Northwestern Great Plains / Wyoming Basin Foothills

Aquatic Ecological System Type: C001-Small Transitional Foothills River

Key Environmental Factors: 1) Grazing - moderate to high impacts in the immediate riparian (see right photo, cattle crossing). 2) Hydrology - upstream dams or diversions in tributaries of the watershed

Rare or Unique Species: No rare species

Rare Features: No rare features documented

Introduced/Exotic Aquatic Species: Invasive *Orconectes virilis* crayfish in the reach.

Overall Ecological Site Condition: Fair trending to Poor

Reach Summary: The 150 m reach consisted of a G4 incised stream channel with a cattle crossing at the bottom of the reach. Upstream from this crossing the riparian vegetation (shrubs & grasses) is largely intact on both banks with old cattle damage recovering, but still showing moderate impacts on the upper end of the reach. Silt and other fine sediment deposits have eliminated much of the geomorphic fish holding habitat in this stream reach. Cobbles are moderately embedded.





Cattle in a dry stream bed on N. Cherry Creek tributary to South Fork Bridger Creek

Fish Community: 3 fish species were shocked or seined in the 2 riffle/run/pool sequences.

Fish Community Quality: O/E = 3/4 or 75% of the expected fish community

Macroinvertebrate Community: This community is dominated by the Medium Coolwater Transitional Assemblage (#1, Stagliano 2005) and members of the Small Foothills Transitional Assemblage (#105, Stagliano 2005). Over 60% of the indicator species were present in this sample.

Macroinvertebrate Community Quality: MT
MMI= 37.3

Silvertip Creek #1 (upstream WY border site)

Location: Accessed from Silvertip road on the east side of stream at BLM parcels.

Ecoregion: Northwestern Great Plains / Wyoming Basin Foothills

Aquatic Ecological System Type: D005-Northwestern Great Plains Intermittent Stream

Key Environmental Factors: Oil and gas deposits in the sediments, oil and gas drilling upstream, Hydrology - upstream dams or diversions in tributaries of the watershed; Grazing - low impacts,

Rare or Unique Species: No rare species

Rare Features: No rare features documented

Introduced/Exotic Aquatic Species: None documented

Overall Ecological Site Condition: Poor, Seriously Degraded (Toxic and Anoxic)



Reach Summary: The 150 m reach consisted of a G6 incised stream channel with recently flooded wetted mud from a rain storm event ~1 week prior. Silt and other fine sediment deposits have eliminated most of the geomorphic fish holding habitat in this stream reach. Riparian vegetation (grasses, sedges) is largely intact on both banks with old cattle damage recovering, but there are still moderate impacts on the upper end of the reach. Livestock use index (LUI) was slight-moderate with ~ 5 cow pies counted on a 75m walk of the left and right bank. Pugging and hummocking was extensive at one upper site of the reach. No amphibians or reptiles were noted while walking the reach, although a prairie rattlesnake, *Crotalus viridus* was spotted on the terrace above the stream.

Reach Riparian Ranking: BLM = 63.5% (14 of 24) EPA RBP = 62.5% (116 of 200)

Fish Community: No fish species were shocked or seined in the 2 riffle/run/pool sequences.

Fish Community Quality: IBI = 0 O/E = 0/4 or 0% of the expected fish community

Macroinvertebrate Community: This community of intermittent prairie stream invertebrates consists of a severely impaired Prairie Pool assemblage (#12, Stagiano 2005). Only (4spp. collected) 5% of the indicator species were present in this sample.

Macroinvertebrate Community Quality: MT MMI = 18.2

Silvertip Creek #2 (downstream bridge site)

Location: Accessed from Silvertip road on the east side of stream at BLM parcels.

Ecoregion: Northwestern Great Plains / Wyoming Basin

Aquatic Ecological System Type: D005-Northwestern Great Plains Intermittent Stream

Key Environmental Factors: Oil and gas deposits in the sediments, oil and gas drilling upstream, Hydrology - upstream dams or diversions in tributaries of the watershed; Grazing - low impacts

Rare or Unique Species: No rare species

Rare Features: No rare features documented

Introduced/Exotic Aquatic Species: No exotic species documented

Overall Ecological Site Condition: Poor, Seriously Degraded (Toxic and Anoxic, Petrol Smell)

Reach Summary:

The 150 m reach consisted of a G6 incised stream channel with recently flooded wetted mud from a rain storm event ~1 week prior (left photo). Silt and other fine sediment deposits have eliminated most of the geomorphic fish holding habitat in this stream reach. Riparian vegetation (grasses, sedges) is largely intact on both



banks with old cattle damage recovering, but there are still moderate impacts on the upper end of the reach. Livestock use index (LUI) was moderate to severe with ~18 old cow pies counted on a

75m walk of the left and right bank. Pugging and hummocking was extensive at one upper site of the reach. No amphibians or reptiles were noted while walking the reach. The sediments are anoxic and toxic

All substrate of the pools was silt dominated with some gravel/pebble in the runs between them; the lower pools contain some pebble/cobble riffle areas between them, which provided the highest habitat diversity for macroinvertebrates. The surrounding vegetation dominated by *Scirpus sp.* (rushes) and *Eleocharis palustris*, the common spikerush.

Reach Riparian Ranking: BLM = 63.5% (15 of 24) EPA RBP = 62.5% (127 of 200)

Fish Community: No fish species were shocked or seined in the 2 riffle/run/pool sequences.

Fish Community Quality: IBI = 0 O/E = 0/4 or 0% of the expected fish community

Macroinvertebrate Community: This community of intermittent prairie stream invertebrates consisted of the Prairie Pool assemblage (#12, Stagliano 2005) and the Prairie Stream assemblage found in the cobble riffle areas (#9, Stagliano 2005). Over 80% of the indicator species were present in this sample.

Macroinvertebrate Community Quality: MT MMI (2004) = 31.4 (2007) = 52.4

Grove Creek (BLM Section)

Location: Approximately 4 miles west on Grove Creek Rd. off of Rt 72, BLM section

Ecoregion: Northwestern Great Plains / Wyoming Basin

Aquatic Ecological System Type: D005-Northwestern Great Plains Intermittent Stream

Key Environmental Factors: Hydrology - upstream dams or diversions in tributaries of the watershed; Grazing - moderate to severe impacts, pocking and hummocking

Rare or Unique Species: No rare species

Rare Features: No rare features documented

Introduced/Exotic Aquatic Species: None documented

Overall Ecological Site Condition: Fair (2005) trending to Poor (2007)



Fish Community: No fish species were shocked in the 2 run/pool sequences. Lake chubs have been previously reported near this reach.

Fish Community Quality: IBI = 0 O/E = 0/4 or 0% of the expected fish community

Macroinvertebrate Community: This community of prairie stream invertebrates consisted of the Prairie Pool assemblage (#12, Stagliano 2005) and the Prairie Stream assemblage found in the

woody debris cobble areas (#9, Stagliano 2005). Over 70% of the indicator species were present in the 2005 sample.

Macroinvertebrate Community Quality: MT MMI (2005) = 72.6 (2007) = 42.4

Gold Creek(dry)

Ecoregion: Pryor/Bighorn Mountain Foothills - Northwestern Great Plains Montana Foothills and Valleys

Aquatic Ecological System Type: D001-Small Foothills Stream

Key Environmental Factors: Hydrology - upstream dams or diversions in tributaries of the watershed; Riparian Grazing - moderate impacts

Rare or Unique Species: No rare species

Rare Features: No rare features documented

Introduced/Exotic Aquatic Species: None collected

Overall Ecological Site Condition: Fair trending to Poor

Reach Riparian Ranking: BLM = NA EPA RBP = NA

Fish Community: No fish species collected, stream reaches dry. Expected fish have not been met.

Fish Community Quality: IBI = 0 O/E = 0 / 2.7 or 0% of the expected fish community

Macroinvertebrate Community: No macroinvertebrate species collected stream reaches dry.

Macroinvertebrate Community Quality: MMI = 0 O/E = 0%

North Fork Grove Creek

Location: upper boundary of BLM getting near the FS, pure snowmelt

Ecoregion: Pryor / Bighorn Mountain Foothills

Aquatic Ecological System Type: D001-Small Foothills Stream

Key Environmental Factors: Hydrology - upstream dams or diversions in tributaries of the watershed; Riparian Grazing - moderate impacts



Rare or Unique Species: No rare species

Rare Features: No rare features documented

Introduced/Exotic Aquatic Species: None collected

Overall Ecological Site Condition: Good

Reach Summary: The 150 m reach appears to be flowing with pure snowmelt run-off, as no fish have colonized recently; macroinvertebrate diversity and numbers are low as well. Livestock use index (LUI) was minimal with ~2 old cow pies counted on a 75m walk of the left and right bank..

Reach Geomorphology: The geomorphology of this stream is a riffle run configuration with a moderate slope (~2%), moderate sinuosity. Substrate is dominated with cobbles some gravel/pebble in the slower runs between them; the lower pools contain pebble/cobble riffle areas between them.

Reach Riparian Ranking: BLM = 87.5% (21 of 24) EPA RBP = 90.5% (178 of 200)

Fish Community: No fish species were shocked in the 150 m reach sequence.

Fish Community Quality: IBI = 0 O/E = 0/4 or 0% of the expected fish community

Macroinvertebrate Community: This community of coldwater stream invertebrates consisted of the Mountain Stream assemblage (#90, Stagliano 2005), but in really low numbers reflecting recent colonization of a dry stream bed. Only 25% of the indicator species were present in this sample, but the MMI still ranked this site as an excellent biological integrity.

Macroinvertebrate Community Quality: MT MMI= 72.6

Dillworth Creek(sites #1 & 2 dry)

Ecoregion: Pryor/Bighorn Mountain Foothills - Northwestern Great Plains Montana Foothills and Valleys

Aquatic Ecological System Type: D001-Small Foothills Stream

Key Environmental Factors: Hydrology- -upstream dams or diversions in tributaries of the watershed; Riparian Grazing - moderate impacts

Rare or Unique Species: No rare species

Rare Features: No rare features documented

Introduced/Exotic Aquatic Species: None collected.

Overall Ecological Site Condition: Fair trending to Good

Reach Riparian Ranking: BLM = NA EPA RBP = NA

Reach Geomorphology: Surrounding bank materials are finer than the channel bed materials

Fish Community: No fish species collected, stream reaches dry.

Fish Community Quality:

Macroinvertebrate Community: No macroinvertebrate species collected stream reaches dry.

Macroinvertebrate Community Quality: MMI = 0 O/E = 0%

Wolf Creek (sites #1 & 2 dry)

Location: Accessed by traveling west (3-4 miles) off Route 72 from the road across from Bridger Bend FAS (photo right looking upstream). Below the reservoir confluence wolf creek

Nearest Town: Belfry

Ecoregion: Northwestern Great Plains - Pryor/Bighorn Foothills

Aquatic Ecological System Type: D005-Northwestern Great Plains Intermittent Stream

Key Environmental Factors: Hydrology - dry stream bed. Upstream dams or diversions in tributaries of the watershed; Grazing - moderate impacts, some hummocking, especially around the stock pond.

Rare or Unique Species: No rare species

Rare Features: No rare features documented

Introduced/Exotic Aquatic Species: No aquatic species collected, stream reaches dry

Overall Ecological Site Condition: Fair trending to Poor



Reach Riparian Ranking: BLM = NA

EPA RBP = NA

Reach Geomorphology: Surrounding bank materials are finer than the channel bed materials

Fish Community: No fish species collected, stream reaches dry. Expected fish for this stream type have not been met.

Fish Community Quality: IBI = 0 O/E = 0 / 2.7 or 0% of the expected fish community

Macroinvertebrate Community: No macroinvertebrate species collected stream reaches dry.

Macroinvertebrate Community Quality: MMI = 0 O/E = 0%

Gyp Spring

Ecoregion: Wyoming Basin (Typical)

Aquatic Ecological System Type: S005-Wyoming Basin Perennial Spring

Key Environmental Factors: Hydrology - upstream dams or diversions affecting groundwater recharge for the spring watershed; Grazing - slight impacts, mostly fenced-but some intrusions

Rare or Unique Species: An oasis of a biologically healthy spring community of aquatic insects within a desert landscape

Rare Features: A spring oasis.

Introduced/Exotic Species: None documented

Overall Ecological Site Condition: Good



Reach Riparian Ranking: BLM = 91.6% (22 of 24) EPA RBP = 86% (172 of 200)

Fish Community: No fish species collected or expected.

Fish Community Quality: IBI = 0 O/E = 0 / 0 or 0% of the expected fish community

Macroinvertebrate Community: The macroinvertebrate community is consisted with a Northwestern Great Plains/Wyoming Basin Perennial Spring Assemblage resembling species found in other springs in the region.

Macroinvertebrate Community Quality: MMI = 66.5